SUBJECT

Board Policy III.V, Articulation and Transfer – First Reading

REFERENCE

October 2012	The Board approved the first reading of proposed amendments to Board Policy III.V, which provided flexibility in six credits required of the general education core that are not assigned to a specific discipline.
December 2012	The Board approved the second reading of proposed amendments to Board policy III.V.
April 2015	The Board approved the first reading of proposed amendments to Board Policy III.V, which clarified the transfer and articulation policy for general education credit applies to all Idaho public institutions.
June 2015	The Board approved the second reading of proposed amendments to Board Policy III.V.
April 2019	The Board approved the first reading of proposed amendments to Board Policy III.V. which clarified the credit awarded by an institution for prior learning and transfer of general education requirements.

APPLICABLE STATUTES, RULE OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.V., and III.N.

ALIGNMENT WITH STRATEGIC PLAN

GOAL 1: EDUCATIONAL SYSTEM ALIGNMENT – Objective B: Alignment and Coordination

BACKGROUND/DISCUSSION

Board Policy III.V, Articulation and Transfer, establishes requirements for the articulation and transfer of courses between Idaho's public postsecondary institutions. Proposed amendments to Board Policy III.V add a requirement that credits awarded through a prior learning assessment (PLA) by one of the institutions for a course on the common course list or for meeting a general education requirement shall transfer between those institutions as the same course on the list and/or meet the same general education requirement.

IMPACT

Approval of proposed amendments will provide institutions and staff with necessary guidance for transfer of course credits awarded through PLA. It will also provide maximum transparency and consistency for course articulation across institutions. This will help ensure students are provided with an opportunity to complete their degree in a timely manner without the need to repeat courses or to submit requests for evaluation of PLA credit awarded at a prior institution.

Furthermore, amendments conform with Section 33-3729, Idaho Code ensuring completion of the Board's general education requirements for students who earn an Associate of Arts or Associate of Science degree from any institution within or external to Idaho, which is regionally accredited by a body recognized by the Board.

ATTACHMENTS

Attachment 1 – Board Policy III.V, Articulation and Transfer – 2nd Reading

STAFF COMMENTS AND RECOMMENDATIONS

Proposed amendments to Board Policy III.V will provide for the seamless transfer of credits earned through PLA consistently across Idaho's public postsecondary institutions. Furthermore, Section 33-3729, Idaho Code requires Idaho postsecondary institutions to recognize students who complete an Associate of Arts or Associate of Science degree at any institution accredited by a body recognized by the Board as having completed the Board's general education requirements and prohibits the institutions from requiring these students to complete any additional general education requirements. One technical correction was made to section 2.C. No other changes were made between the first and second reading. Board staff recommends approval as presented.

BOARD ACTION

I move to approve the second reading of proposed amendments to Board Policy III. V, Articulation and Transfer as submitted in Attachment 1.

Moved by _____ Seconded by _____ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES

SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: V. Articulation and Transfer **June 2019~~5~~**

This subsection shall apply to the University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho, and North Idaho College.

The Statewide General Education Policy, Board Policy III.N, Statewide General Education, outlines Idaho's General Education Framework and establishes guidelines for General Education Matriculated (GEM) curricula across all public postsecondary institutions. Statewide recognition of common GEM competencies creates a transparent and seamless transfer experience for undergraduates as defined in Board Policy III.N.

The transfer of GEM courses is predicated on the acquisition of competencies in broad academic areas. Each institution recognizes the professional integrity of all other public institutions in the acceptance of their general education courses and programs.

1. Statewide Articulation

   a. Academic Undergraduate Degrees

      i. Students who complete requirements for the Associate of Arts or Associate of Science degree at a regionally accredited postsecondary institution ~~in Idaho~~ will be considered as satisfying the general education requirement, as defined in Board Policy III.N., upon transfer to a ~~four-year~~ public institution in Idaho and will not be required to complete any additional general education requirements.

      ii. Students who have completed the 36-credit General Education Framework, as defined in Board Policy III.N, without an Associate of Arts or Associate of Science Degree and transfer from a regionally accredited postsecondary institution in Idaho will not be required to complete additional general education requirements at the receiving institution.

      iii. If a student has completed a GEM course(s) but has not completed the entire General Education Framework or an Associate of Arts or Associate of Science Degree, those GEM courses will be applied towards the associated GEM competency requirements at the receiving institution.

   b. Associate of Applied Science (AAS) Degrees

      i. A student who satisfactorily completes a GEM course(s) as part of the Associate of Applied Science (AAS) degree and then subsequently transfers to another public Idaho postsecondary institution will have those GEM courses

will be applied towards the associated GEM competency of the receiving institution.

ii. A student who completes an AAS degree may pursue an interdisciplinary Bachelor of Applied Science or a Bachelor of Applied Technology degree focused on upper-level academic coursework.

2. Authority is delegated to the postsecondary institutions under the Board's governance to evaluate and determine whether to accept equivalent or elective credits on behalf of transferring students within the requirements of sections 33-107(6)(bc) and 33-2102, and 33-3729 Idaho Ccode and Board Policy III.V.2.c through ed. Each institution is responsible for working to facilitate the effective and efficient transfer of students. To that end:

a. Institutions shall publish the current curriculum equivalencies of all courses on the state transfer web portal.

b. Where patterns of student enrollment are identified between institutions, articulation agreements shall be developed between the institutions.

c. Non-remedial course credits earned at an those institutions under the Board's governance, regardless of being a general education credit or not, are transferable to any other institution governed by this policy.

d. Academic credits accepted from a regionally accredited institution into an academic program by one institution under the Board's governance shall transfer from two- and four-year to four-year institutions as either equivalent or elective credits between the other postsecondary institutions governed by this policy.

e. Courses on the common course index list, as provided in Board Policy III.N.6.b, that are awarded credit through prior learning assessments, as outlined in Board Policy III.L.1.b, from an institution shall transfer as equivalent course credit between those institutions. An area of general education, as listed in Board Policy III.N.3, for which credit is awarded by an institution through prior learning assessments, shall transfer across those institutions as meeting the same general education requirement.

BOISE STATE UNIVERSITY

SUBJECT

Online Graduate Certificate in Computer Assisted Language Learning (CALL)

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.G. and Section V.R.

ALIGNMENT WITH STRATEGIC PLAN

Goal 2: Educational Attainment – Objective A: Higher Level of Educational Attainment and Objective C: Access

BACKGROUND/DISCUSSION

Boise State University (BSU) proposes to create a new Graduate Certificate in Computer Assisted Language Learning that will be offered entirely online. The program will operate under the guidelines of the Idaho State Board of Education Policy V.R. as it pertains to wholly online programs. The online format of the program and the flexibility it affords a student who may have family responsibilities, or live in a rural county, contribute to a higher level of educational attainment for Idaho residents as they can take advantage of a graduate-level certificate despite these factors. The wholly online format of the proposed graduate certificate is accessible to Idaho students regardless of socioeconomic status, age, and geographic location. The proposed program will target Idaho foreign language teachers by providing an opportunity to enhance their professional careers through graduate-level coursework in second language teaching methodology and innovative educational technologies.

Because it is wholly online, the proposed program will enable BSU to reach potential students, many of whom are Idaho teachers and who need flexibility in their education that result from professional and personal responsibilities. These students may also live in a rural area of Idaho that does not have face-to-face educational opportunities.

IMPACT

The program's size can be scaled to demand for the program, and BSU projects that the program will reach a size of 15 students by the sixth year, graduating approximately 20 students per year once the program is up and running. As the program is designed for working professionals it is expected most students will be part-time.

The student fee will be in accordance with the Online Program Fee as defined in the Board Policy V.R., 3.a.x. We will initially charge $478 per credit hour. For the 12 credits required for completion of the proposed program, students will pay $478 per credit; the total cost of those 12 credits totals $5,736.

ATTACHMENTS

Attachment 1 – Proposal, Graduate Certificate in Computer Assisted Language Learning

STAFF COMMENTS AND RECOMMENDATIONS

BSU anticipates a projected enrollment of seven students initially. Because program will be using the online program fee model, minimum enrollments are based on course registrations. The capacity for the program is 20 students, which can be scaled to demand for the certificate. BSU has identified a minimum of eight enrollments for program continuance. If that number is not consistently achieved after five years, the certificate will be discontinued.

BSU's proposed Graduate Certificate in Computer Assisted Language Learning is consistent with their Service Region Program Responsibilities and their current institution plan for Delivery of Academic Programs in Region III. As provided in Board Policy III.Z, no institution has the statewide program responsibility for educational technology programs. Additionally, Board Policy III.Z does not apply to programs for which 90% or more of all activity is required or completed online.

BSU also requests approval to assess an online program fee consistent with Board Policy V.R.3.a.x. BSU proposes to charge $478 per credit for a total program cost of $5,736 for 12 required credits. The establishment of the online program fee was based on the fee currently assessed by BSU's Educational Technology graduate program. Based on the information for the online program fee provided in the proposal, staff finds that the criteria have been met for this program.

The proposal completed the program review process and was recommended for approval by the Council on Academic Affairs and Programs (CAAP) on May 9, 2019; and was presented to the Committee on Instruction, Research, and Student Affairs (IRSA) on May 21, 2019; and to the Business Affairs and Human Resources (BAHR) Committee on June 7, 2019. The BAHR Committee is currently in the process of reevaluating Board Policy V.R., Establishment of Fees, which includes educational and technical program fees.

Board staff recommends approval.

BOARD ACTION

I move to approve the request by Boise State University to create an online Graduate Certificate in Computer Assisted Language Learning as presented in Attachment 1.

Moved by _____ Seconded by _____ Carried Yes _____ No _____

AND

I move to approve the request by Boise State University to charge an online program fee of $478 per credit for students enrolled in the wholly online Graduate Certificate in Computer Assisted Language Learning program.

Moved by _____ Seconded by _____ Carried Yes _____ No _____

Idaho State Board of Education

Proposal for **Undergraduate/Graduate Degree** Program

Date of Proposal Submission:	February 27 2019
Institution Submitting Proposal:	Boise State University
Name of College, School, or Division:	College of Arts and Sciences
Name of Department(s) or Area(s):	Department of World Languages

Program Identification for Proposed New or Modified Program:

Program Title:	Graduate Certificate in Computer Assisted Language Learning						
Degree:		Degree Designation		Undergraduate	X	Graduate	
Indicate if Online Program:	X	Yes		No			
CIP code (consult IR /Registrar):	16.0101						
Proposed Starting Date:	Fall 2019						
Geographical Delivery:	Location(s)	Online Only		Region(s)	Online Only		
Indicate (X) if the program is/has:	X	Self-Support (Online Program Fee)			Professional Fee		
Indicate (X) if the program is:	X	Regional Responsibility			Statewide Responsibility		

Indicate whether this request is either of the following:

- [ ] New Degree Program
- [X] Undergraduate/Graduate Certificates (30 credits or more)
- [ ] Expansion of Existing Program
- [ ] Consolidation of Existing Program
- [ ] New Off-Campus Instructional Program
- [ ] Other (i.e., Contract Program/Collaborative

College Dean (Institution)	Date	Vice President for Research (Institution; as applicable)	Date
Graduate Dean or other official (Institution; as applicable)	Date	Academic Affairs Program Manager, OSBE	Date
FVP/Chief Fiscal Officer (Institution)	Date	Chief Academic Officer, OSBE	Date
Provost/VP for Instruction (Institution)	Date	SBOE/Executive Director Approval	Date
President	Date		

2/13/19
2/14/19
2/20/19
2/27/19
2/27/19

Before completing this form, refer to Board Policy Section III.G., Postsecondary Program Approval and Discontinuance. This proposal form must be completed for the creation of each new program. All questions must be answered.

Rationale for Creation or Modification of the Program

1. **Describe the request and give an overview of the changes that will result.** Will this program be related or tied to other programs on campus? Identify any existing program that this program will replace.

The Departments of World Languages and Educational Technology jointly propose to create a 12-credit online graduate certificate in Computer Assisted Language Learning (CALL). The proposed program will operate under the guidelines of SBOE Policy V.R. as it pertains to wholly online programs. The online graduate certificate would be comprised of coursework in Applied Linguistics, Second Language Pedagogy, and Educational Technologies offered by both departments. The proposed start date is fall 2019.

There is currently no opportunity for World Languages teachers to pursue graduate study in the State of Idaho. This program would provide an important first step toward supporting our teachers with graduate instruction in their field of expertise by providing a sound foundation in second language teaching methodology and innovative educational technologies. Students wishing to pursue a Master's Degree in Educational Technology could count the coursework for the CALL graduate certificate toward their M.Ed. The department of Educational Technology's Master of Educational Technology program is one of the largest education master's degree in the United States. The department has four other graduate certificates, which can be taken as specializations within the master's program or as a stand-alone program. This proposed program will continue to build on the Boise State's Ed Tech brand. Greater choice infers greater size and credibility; therefore, curricular choice plays a key role in student recruitment.

2. **Need for the Program**. Describe the student, regional, and statewide needs that will be addressed by this proposal and address the ways in which the proposed program will meet those needs.

   a. **Workforce need:** Provide verification of state workforce needs that will be met by this program. Include State and National Department of Labor research on employment potential. Using the chart below, indicate the total projected annual job openings (including growth and replacement demands in your regional area, the state, and nation. Job openings should represent positions which require graduation from a program such as the one proposed. Data should be derived from a source that can be validated and must be no more than two years old.

      List the job titles for which this degree is relevant:

      1. World Language Teacher

      2. World Language Professor (SOC 25-1124)

	State DOL data	Federal DOL data	Other data source: (describe)
Local (Service Area)	10 (50% of state)	8 (0.25% of national)	n/a
State	20	16 (0.5% of national)	n/a
Nation	n/a	3,200	n/a

Provide (as appropriate) additional narrative as to the workforce needs that will be met by the proposed program.

Although one will find few job announcements that specifically require graduation with a certificate in CALL, this program is designed for instructors of foreign languages at all levels, and all instructors are expected to be proficient in instructional technologies. According to the U.S. Department of Labor, the national projected growth rate for university-level language professors between 2014 and 2024 is 13%, which is "faster than average," and the projected growth rate for High School Teachers is 6% or 961,600 jobs. In Idaho, the state Department of Labor projects a growth rate of 18.8. % for High School Foreign Languages teachers.

The CALL graduate certificate is intended to meet employment needs in the sense that all instructors are expected to be proficient in instructional technologies. This program would thus increase students' employment prospects and improve their ability to perform their job.

b. Student need. What is the most likely source of students who will be expected to enroll (full-time, part-time, outreach, etc.). Document student demand by providing information you have about student interest in the proposed program from inside and outside the institution. If a survey of s was used, please attach a copy of the survey instrument with a summary of results as **Appendix A.**

Within Idaho, the proposed graduate certificate will be promoted to elementary and high school teachers through the Idaho Association of Teachers of Language and Culture (IATLC), as well as through district coordinators throughout the state.

Given that the market for this proposed graduate certificate is also national in scope, we will promote this new program to educators who frequent special interest groups in social media, web sites, and conferences. In particular, we plan to advertise through the American Council on the Teaching of Foreign Languages (ACTFL).

c. Economic Need: Describe how the proposed program will act to stimulate the state economy by advancing the field, providing research results, etc.

Any effort in the state to increase a teacher's ability to effectively and creatively deliver language learning content, thereby increasing the number of Idahoans that are proficient in a second or third language has an economic impact for the state of Idaho. When more Idahoans can communicate in multiple languages they will find their employment opportunities increase as they have a valuable skill companies need in their employees. Additionally, these companies can

more effectively seek business opportunities overseas, helping to make Idaho a more significant player in the global economy.

d. Societal Need: Describe additional societal benefits and cultural benefits of the program.

Coursework focus on the utilization of technologies that help teach students. Classroom applications such as these are intended to stimulate learning. Nevertheless, strengthening the educational system in Idaho will yield long-term economic benefits for the state.

e. If Associate's degree, transferability:

N/A

3. Similar Programs. Identify similar programs offered within Idaho and in the region by other in-state or bordering state colleges/universities.

There are no similar existing programs in the state.

Similar Programs offered by Idaho public institutions (list the proposed program as well)		
Institution Name	**Degree name and Level**	**Program Name and brief description if warranted**
N/A	**N/A**	**N/A**

Similar Programs offered by other Idaho institutions and by institutions in nearby states		
Institution Name	**Degree name and Level**	**Program Name and brief description if warranted**
Arizona State University	Graduate Certificate in CALL	IN PERSON ONLY: 15 credits, focuses on using technology in foreign language teaching and research.
University of Arizona	Graduate Certificate in Technology in Second Language Teaching	IN PERSON ONLY: 15 credits, introduction to various classroom and language-learning technologies and how they are used to assist second language acquisition and second language teaching

4. Justification for Duplication with another institution listed above. (if applicable). If the proposed program is similar to another program offered by an Idaho public institution, provide a rationale as to why any resulting duplication is a net benefit to the state and its citizens. Describe why it is not feasible for existing programs at other institutions to fulfill the need for the proposed

program.

N/A

5. Describe how this request supports the institution's vision and/or strategic plan.

The mission of the graduate certificate in CALL would align in several ways with the university's mission. One of the university's stated strategies for achieving the goals of "Focus on Effectiveness" is to "Facilitate respect for the diversity of human cultures, institutions, and experiences in curricular and co-curricular education." As the study of languages is inextricably linked to the study of the cultures from which they emerge, the Department of World Languages is one of the primary academic units on campus charged with carrying out this aspect of the strategic plan, and the coursework that would lead to the graduate certificate would directly support our mission by offering advanced training in the overlapping fields of Linguistics and Educational Technology with the aim of enhancing the expertise of language instructors in Idaho and across the nation. Another component of Boise State's strategic plan is to support interdisciplinary collaboration and transdisciplinary degree programs. This certificate would rely on interdepartmental collaboration and cross disciplinary boundaries by drawing on research in the fields of Applied Linguistics and Educational Technology.

6. Assurance of Quality. Describe how the institution will ensure the quality of the program. Describe the institutional process of program review. Where appropriate, describe applicable specialized accreditation and explain why you do or do not plan to seek accreditation.

The following measures will ensure the high quality of the new program:

Regional Institutional Accreditation: Boise State University is regionally accredited by the Northwest Commission on Colleges and Universities (NWCCU). Regional accreditation of the university has been continuous since initial accreditation was conferred in 1941. Boise State University is currently accredited at all degree levels (A, B, M, D).

Program Review: Boise State has instituted a new program review procedure. At the inception of new programs, the programs will submit to the Office of the Provost a three-year assessment plan to be scheduled into the Periodic Review/Assessment Reporting Cycle. The plan includes program learning outcomes; and an implementation plan with a timeline identifying when and what will be assessed, how the programs will gather assessment data, and how the program will use that information to make improvements. Then, every three years, the programs will provide Program Assessment Reports (PAR), which will be reviewed by a small team of faculty and staff using a PAR Rubric, which includes feedback, next steps, and a follow-up report with a summary of actions.

Student Authentication: Because the proposed certificate program will be offered entirely online, it is important to include mechanisms by which we authenticate the identity of students enrolled in the program. We will use the following mechanisms:

- During the admissions process, the university will confirm required official transcripts and other documentation required for admission into the program.
- Associated with access to and use of our Learning Management System, a secure log-in environment will be provided and students will be required to use strong passwords and change them every 90 days.

- When high-stakes exams are required, faculty will be encouraged to utilize remote or online proctoring services when appropriate. In those instances, students will need to provide valid photo identification before gaining access to the graded assessments or other required activities.
- Instructors will utilize Blackboard's Safe Assignment plagiarism detection program when appropriate.
- Instructors are expected to be informed of and aware of the importance of student identity authentication and to report and act upon suspected violations.

7. In accordance with Board Policy III.G., an external peer review is required for any new doctoral program. Attach the peer review report as **Appendix B**.

N/A

8. Teacher Education/Certification Programs All Educator Preparation programs that lead to certification require review and recommendation from the Professional Standards Commission (PSC) and approval from the Board.

Will this program lead to certification?
Yes_____ No_X___

If yes, on what date was the Program Approval for Certification Request submitted to the Professional Standards Commission?

9. Five-Year Plan: Is the proposed program on your institution's approved 5-year plan? Indicate below.

Yes ____ No X

Proposed programs submitted to OSBE that are not on the five-year plan must respond to the following questions and meet at least one criterion listed below.

a. Describe why the proposed program is not on the institution's five year plan. When did consideration of and planning for the new program begin?

Graduate certificate programs are not required to be listed on institution's 5 year plans.

b. Describe the immediacy of need for the program. What would be lost were the institution to delay the proposal for implementation of the new program until it fits within the five-year planning cycle? What would be gained by an early consideration?

Criteria. As appropriate, discuss the following:

i. How important is the program in meeting your institution's regional or statewide program responsibilities? Describe whether the proposed program is in response to a specific industry need or workforce opportunity.

As a metropolitan research university in the most heavily populated area of Idaho, we have a responsibility to support K-12 teachers in all disciplines who seek to obtain

additional expertise. There is currently no opportunity for World Languages teachers to pursue graduate study in the State of Idaho. This program would provide an important first step toward supporting our teachers with graduate instruction in their field of expertise, and will be available to instructors of all languages.

ii. Explain if the proposed program is reliant on external funding (grants, donations) with a deadline for acceptance of funding.

N/A

iii. Is there a contractual obligation or partnership opportunity to justify the program?
N/A

iv. Is the program request or program change in response to accreditation requirements or recommendations?
N/A

v. Is the program request or program change in response to recent changes to teacher certification/endorsement requirements?

N/A

Curriculum, Intended Learning Outcomes, and Assessment Plan

10. Curriculum for the proposed program and its delivery.

a. Summary of requirements. Provide a summary of program requirements using the following table.

Credit hours in required courses offered by the department (s) offering the program.	12
Credit hours in required courses offered by other departments:	0
Credit hours in institutional general education curriculum	0
Credit hours in free electives	0
Total credit hours required for degree program:	12

b. Additional requirements. Describe additional requirements such as comprehensive examination, senior thesis or other capstone experience, practicum, or internship, some of which may carry credit hours included in the list above.

None.

11. Program Intended Learning Outcomes and Connection to Curriculum.

a. Intended Learning Outcomes. List the Intended Learning Outcomes for the proposed program, using learner-centered statements that indicate what will students know, be able to do, and value or appreciate as a result of completing the program.

This program addresses the need for Foreign Language Teachers at all levels to be able to effectively implement technology in the language classroom.

Specific program learning outcomes include:

1. Describe, discuss and synthesize contemporary theories of Second Language Development (SLD).
2. Evaluate instructional technologies through the lens of the world language classroom and predict the potential for augmented language development.
3. Articulate a pedagogical framework for language learning where instructional technologies can be integrated appropriately and successfully.
4. Design a Web 2.0 technology that contributes to the growing field of Computer Assisted Language Learning (CALL) or develop a comprehensive curriculum that integrates SLD and CALL successfully and appropriately for your classroom context.

12. Assessment plans

a. Assessment Process. Describe the assessment process that will be used to evaluate how well students are achieving the intended learning outcomes of the program.

The program will use required student Portfolios to map student work (Portfolio artifacts) to specific student learning outcomes. The Program Director will use a rubric to review the artifacts to determine the degree to which student learning outcomes have been met and how curriculum might be altered in the future to improve student learning.

b. Closing the loop. How will you ensure that the assessment findings will be used to improve the program?

Data will be shared with the Departmental Steering Committee and actions will be developed to address concerns that are raised.

c. Measures used. What direct and indirect measures will be used to assess student learning?

Direct measures will include assessment of e-portfolios, lesson plans, and classroom activities as well as classroom observations.

d. Timing and frequency. When will assessment activities occur and at what frequency?

Assessment of outcomes for a particular course will occur each time the course is offered. Assessment of all program outcomes will be assessed on a three-year cycle as by submitting Program Assessment Reports to the university.

Enrollments and Graduates

13. Existing similar programs at Idaho Public Institutions. Using the chart below, provide enrollments and numbers of graduates for similar existing programs at your institution and other Idaho public institutions.

Existing Similar Programs: Historical enrollments and graduate numbers								
Institution and Program Name	**Fall Headcount Enrollment in Program**				**Number of Graduates From Program (Summer, Fall, Spring)**			
	FY__	FY__	FY__	FY__ (most recent)	FY__	FY__	FY__	FY__ (most recent)
BSU	N/A							
ISU	N/A							
UI	N/A							
LCSC	N/A							

14. Projections for proposed program: Using the chart below, provide projected enrollments and number of graduates for the proposed program:

Proposed Program: Projected Enrollments and Graduates First Five Years											
Program Name: Graduate Certificate Computer Assisted Language Learning											
Projected Fall Term Headcount Enrollment in Program						**Projected Annual Number of Graduates From Program**					
FY20	FY21	FY22	FY23	FY24	FY25	FY20 (first year)	FY21	FY22	FY23	FY24	FY25
7	10	12	15	15	15	0	5	7	9	12	12

15. Describe the methodology for determining enrollment and graduation projections. Refer to information provided in Question #2 "Need" above. What is the capacity for the program? Describe your recruitment efforts? How did you determine the projected numbers above?

This program is designed for working professionals, so all new students will be assumed to be part-time. Given the proposed course offering rotation, it will be possible to complete the program within 13 months. The first course will be offered in summer 2019, so the first possible graduation would be summer 2020. We anticipate that some students will take courses only during the summer, so not all students enrolled in year 1 will graduate in 13 months. The capacity for the program according to the planned course schedule is 20 students. If demand increases is beyond 20 students per year, we will consider the possibility of teaching FORLNG 510 and 520 annually

rather than biennially. The projected numbers are based on current enrollments in FORLNG 410, an undergraduate language teaching methodology course, as well as recent enrollments in professional development workshops offered by the department, which have exceeded 50.

16. Minimum Enrollments and Graduates. Have you determined minimums that the program will need to meet in order to be continued? What are those minimums, what is the logical basis for those minimums, what is the time frame, and what is the action that would result?

The minimum enrollment necessary for the program to support itself through the online fee model is 8 students. This number of students will generate sufficient revenue to pay the instructor a full summer salary according to the standard formula for calculating summer pay for full-time instructors. If, after two years, enrollments are lower than 8 students in these classes and there is insufficient carry-forward to pay the full summer salary for the course, the instructor will be asked to prorate their summer salary or cancel the course. If, after five years, enrollments are regularly insufficient and the instructor chooses to cancel the class rather than prorate on a regular basis, the program will be discontinued.

Resources Required for Implementation – fiscal impact and budget

17. Physical Resources.

a. Existing resources. Describe equipment, space, laboratory instruments, computer(s), or other physical equipment presently available to support the successful implementation of the program.

The department already possesses the computer equipment needed to deliver the new courses for this program.

b. Impact of new program. What will be the impact on existing programs of increased use of physical resources by the proposed program? How will the increased use be accommodated?

No impact

c. Needed resources. List equipment, space, laboratory instruments, etc., that must be obtained to support the proposed program. Enter the costs of those physical resources into the budget sheet.

None needed.

18. Library resources

a. Existing resources and impact of new program. Evaluate library resources, including personnel and space. Are they adequate for the operation of the present program? Will there be an impact on existing programs of increased library usage caused by the proposed program? For off-campus programs, clearly indicate how the

library resources are to be provided.

Current library resources are adequate. No additional library space or personnel will be required. No impact on existing programs is anticipated. Students will use the library primarily by accessing existing databases.

b. Needed resources. What new library resources will be required to ensure successful implementation of the program? Enter the costs of those library resources into the budget sheet.

No new library resources will be required.

19. Personnel resources

a. Needed resources. Give an overview of the personnel resources that will be needed to implement the program. How many additional sections of existing courses will be needed? Referring to the list of new courses to be created, what instructional capacity will be needed to offer the necessary number of sections?

The two new courses that will be developed for this program, FORLNG 510 and 520, will be offered during the summer, outside of the instructor's 9-month contract. Therefore, the only additional personnel resources needed will be summer salary for the instructor, which will be generated through student fees.

b. Existing resources. Describe the existing instructional, support, and administrative resources that can be brought to bear to support the successful implementation of the program.

The Department of World Languages is already a highly functioning unit with sufficient infrastructure to support one additional summer course offering per year. The Department of Educational Technology employs a full-time advisor who will provide advising services in conjunction with World Languages. The EDTECH courses for this program are already offered and can accommodate additional students.

c. Impact on existing programs. What will be the impact on existing programs of increased use of existing personnel resources by the proposed program? How will quality and productivity of existing programs be maintained?

The impact on existing resources will be minimal because the additional teaching load will occur outside of the regular 9-month contract. Review of applications will require a limited amount of additional service during the regular academic year. This will be offset by the hire of an additional tenure-line colleague in World Languages in another program, which is already assured for FY20. Thus, there should be no impact on quality or productivity of existing programs.

d. Needed resources. List the new personnel that must be hired to support the proposed program. Enter the costs of those personnel resources into the budget sheet.

The instructor who will deliver the two new courses is already employed in the Department of World Languages, so no new hires will be required. They will teach the new courses during the summer, outside of their 9-month contract, and will thus only require summer salary, which will be generated through student fees. The following is the class schedule for 2019-2022:

Summer 2019: FORLNG 510 Summer salary for instructor
Summer 2020: FORLNG 520 Summer salary for instructor
Summer 2021: FORLNG 510 Summer salary for instructor
Summer 2022: FORLNG 520 Summer salary for instructor

EDTECH courses are already offered on a regular basis and will not require additional resources.

20. Revenue Sources

a) **Reallocation of funds:** If funding is to come from the reallocation of existing state appropriated funds, please indicate the sources of the reallocation. What impact will the reallocation of funds in support of the program have on other programs?

N/A

b) **New appropriation**. If an above Maintenance of Current Operations (MCO) appropriation is required to fund the program, indicate when the institution plans to include the program in the legislative budget request.

N/A

c) **Non-ongoing sources**:
   i. If the funding is to come from one-time sources such as a donation, indicate the sources of other funding. What are the institution's plans for sustaining the program when that funding ends?

   N/A

   ii. Describe the federal grant, other grant(s), special fee arrangements, or contract(s) that will be valid to fund the program. What does the institution propose to do with the program upon termination of those funds?

   N/A

d) **Student Fees**:
   i. If the proposed program is intended to levy any institutional local fees, explain how doing so meets the requirements of Board Policy V.R., 3.b.

   The student fee will be in accordance with the Online Program Fee as defined in the Board Policy V.R., 3.a.x. That policy enables the institution to set a price-point appropriate for the program; students will pay an online program fee in lieu of tuition. The price-point for our online program fee will be set at $478 per credit.

   ii. Provide estimated cost to students and total revenue for self-support programs and for professional fees and other fees anticipated to be requested under Board Policy V.R., if applicable.

   For the 12 credits required for completion of the certificate, students will pay an online program fee of $478 per credit. The total cost of those 12 credits would be $5,735.

We project that by the fourth year of the program, it will generate 120SCH, which will yield a total revenue of $57,350.

21. Using the budget template provided by the Office of the State Board of Education, provide the following information:

- Indicate all resources needed including the planned FTE enrollment, projected revenues, and estimated expenditures for the first **four** fiscal years of the program.
- Include reallocation of existing personnel and resources and anticipated or requested new resources.
- Second and third year estimates should be in constant dollars.
- Amounts should reconcile subsequent pages where budget explanations are provided.
- If the program is contract related, explain the fiscal sources and the year-to-year commitment from the contracting agency(ies) or party(ies).
- Provide an explanation of the fiscal impact of any proposed discontinuance to include impacts to faculty (i.e., salary savings, re-assignments).

Program Resource Requirements.

- Indicate all resources needed including the planned FTE enrollment, projected revenues, and estimated expenditures for the first **four** fiscal years of the
- Include reallocation of existing personnel and resources and anticipated or requested new resources.
- Second and third year estimates should be in constant dollars.
- Amounts should reconcile subsequent pages where budget explanations are provided.
- If the program is contract related, explain the fiscal sources and the year-to-year commitment from the contracting agency(ies) or party(ies).
- Provide an explanation of the fiscal impact of any proposed discontinuance to include impacts to faculty (i.e., salary savings, re-assignments).

I. PLANNED STUDENT ENROLLMENT

	FY 20		FY 21		FY 22		FY 23	
	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount
A. New enrollments	2.33	7	5.00	10	5.00	10	5.00	10
B. Shifting enrollments			1.17	7	1.67	10	1.67	10
Total Enrollment	2.33	7	6.17	17	6.67	20	6.67	20

II. REVENUE

	FY 20		FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time	On-going	One-time
1. New Appropriated Funding Reques	$0.00	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2. Institution Funds								
3. Federal	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
4. New Tuition Revenues from Increased Enrollments		$0.00		$0.00				
5. Student Fees		$20,073		$53,049		$57,350		$57,350
6. Other (i.e., Gifts)								
Total Revenue	$0	$20,073	$0	$53,049	$0	$57,350	$0	$57,350

Ongoing is defined as ongoing operating budget for the program which will become part of the base.

One-time is defined as one-time funding in a fiscal year and not part of the base.

Budget Notes:

I.A, B. Calculation of FTE and headcount as follows:

>1 FTE = 18 credits

>Headcount determined as the distinct number of students in the program that year.

II.5. Student Fee revenue calculated as Student Credit Hours * $478 per credit.

III. EXPENDITURES

	FY 20		FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time	On-going	One-time
A. Personnel Costs								
1. FTE	0.0	0.33	0.0	0.50	0.0	0.50	0.0	0.50
2. Faculty		$10,486		$20,982		$21,162		$21,347
3. Adjunct Faculty		$0.00		$0.00		$0.00		$0.00
4. Graduate/Undergrad Assistants		$0.00		$0.00		$0.00		$0.00
5. Research Personnel		$0.00		$0.00		$0.00		$0.00
6. Directors/Administrators								
7. Administrative Support Personnel								
8. Fringe Benefits		$3,565		$7,430		$7,500		$7,572
9. Other:								
Total Personnel and Costs	$0	$14,051	$0	$28,412	$0	$28,662	$0	$28,920

Budget Notes (continued)

III.A.2 9 month faculty FTE: Calculated using (Credit hour load)/18

III.A.8 Benefits calculated: $11,650+(annual wage*20.94%)

	FY 20		FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time	On-going	One-time
B. Operating Expenditures								
1. Travel		$3,700						
2. Professional Services								
3. Other Services								
4. Communications								
5. Materials and Supplies								
6. Rentals								
7. Materials & Goods for Manufacture & Resale								
8. Miscellaneous								
Total Operating Expenditures	$0	$3,700	$0	$0	$0	$0	$0	$0

Budget Notes (continued):

III.B.1 Travel to industry conference in year 1 to market program

	FY 20		FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time	On-going	One-time
C. Capital Outlay								
1. Library Resources	$0.00	$0.00	0	$0.00	$0.00	$0.00	$0.00	$0.00
2. Equipment								
Total Capital Outlay	$0	$0	$0	$0	$0	$0	$0	$0

	FY 20		FY 21		FY 22		FY 23	
D. Capital Facilities Construction or Major Renovation								
E. Indirect Costs (overhead)								
Boise State University Sup	$0.00	$6,022	$0.00	$15,915	$0.00	$17,205	$0.00	$17,205
Maintenance & Repairs	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other								
Total Indirect Costs	$0	$6,022	$0	$15,915	$0	$17,205	$0	$17,205
TOTAL EXPENDITURES:	$0	$23,773	$0	$44,327	$0	$45,867	$0	$46,125
Net Income (Deficit)	$0	-$3,700	$0	$8,723	$0	$11,483	$0	$11,226

Budget Notes:

III.E.1 Boise State University Support is defined as follows:

Boise State Central Services (15.00% of revenue): A fund dedicated to funding support services for online students.

Boise State eCampus Center (11.00% of revenue): Provide funding for initiative management, online course/program development and other support services

Boise State Online Innovation Fund (4.00% of revenue): Seed funding for academic programs, course development stipends to faculty, and eventually innovation grants

Appendix A: Curriculum

Graduate Certificate in Computer Assisted Language Learning	
Course Number and Title	*Credits*
EDTECH 501 Introduction to Educational Technology FORLNG 510 Foundations of Second Language Acquisition FORLNG 520 Foundations of Technology-Enhanced Language Learning	3 3 3
Choose one of the following elective courses: EDTECH 502 Creating Educational Websites EDTECH 503 Instructional Design EDTECH 504 Theoretical Foundations of Educational Technology EDTECH 505 Evaluation for Educational Technologists EDTECH 534 Mobile App Design for Teaching and Learning EDTECH 541 Integrating Technology into the Classroom Curriculum	3
Total	12

SUBJECT

Higher Education Research Council Annual Update

REFERENCE

February 2015	The Board approved changes to the Higher Education Research Strategic Plan.
October 2015	The Board was provided the Performance Measure Report for the Higher Education Research Strategic Plan.
December 2016	The Board approved changes to the Higher Education Research Strategic Plan.
February 2017	The Board was provided the annual update of the Higher Education Research Council.
February 2018	The Board was provided the annual update of the Higher Education Research Council.

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.W., Higher Education Research

ALIGNMENT WITH STRATEGIC PLAN

Goal 3: EDUCATIONAL ATTAINMENT – Objective A: Higher Level of Educational Attainment
Goal 4: WORKFORCE READINESS – Objective A: Workforce Alignment

BACKGROUND/DISCUSSION

Board Policy III.W, Higher Education Research, recognizes the significant role research plays in innovation, economic development and enhanced quality of educational programs. By developing and leveraging the state's unique research expertise and strengths, Idaho's universities and college serve as catalyst to spur the creation of new knowledge, technologies, products and industries. This in turn leads to new advances and opportunities for economic growth.

The Board's Higher Education Research Council (HERC) provides recommendations to the Board regarding statewide collaborative efforts and initiatives to accomplish these goals and objectives. In addition, HERC provides direction for and oversees the use of the limited resources allocated by the Board for higher education research by promoting research activities that will have the greatest beneficial effect on the quality of education and the economy of the state.

The Statewide Strategic Plan for research assists in the identification of research areas that will enhance the economy of Idaho through the collaboration of academia, industry, and government and are in alignment with identified areas of strength at our public universities. Changes to the strategic plan were approved by the Board in December 2016.

The plan represents the role Idaho's research universities play in driving innovation, economic development, and enhancing the quality of educational programs in strategic areas. The plan identifies areas of strength among Idaho's research universities; research challenges and barriers facing the universities; research opportunities Idaho should capitalize upon to further build its research base; goals to build the research pipeline through engaging undergraduate students; and steps for achieving the research vision for Idaho's universities. Additional responsibilities of HERC include the management of the Incubation Fund and HERC IGEM Fund programs, disbursement of Infrastructure Funds and the matching funds for our Idaho EPSCoR Track 1 project (Managing Idaho's Landscapes for Ecosystem Services). Additional responsibilities include receiving annual reporting on the institutions activities in relation to the Center for Advanced Energy Studies (CAES).

Incubation Fund projects are single-year projects that are at the proof-of-concept stage. Through a competitive process, HERC awards funds to those projects where the principal investigator can rapidly move their project into the development stage. IGEM Fund projects are those that are designed to develop spin-off companies. While these awards may be for up to three years, the funding is contingent upon successful progress as determined by HERC at an annual review of the project.

CAES is a research and education consortium between the Idaho National Laboratory, the University of Wyoming, and the three Idaho public research institutions: Boise State University, Idaho State University, and the University of Idaho.

IMPACT

Taking a strategic approach to invest in the state's unique research expertise and strengths will lead to new advances and opportunities for economic growth and enhance Idaho's reputation as a national and international leader in excellence and innovation. This update will provide the Board with the opportunity to provide HERC, through the Council's Chair, input on areas of focus or strategic direction.

ATTACHMENTS

Attachment 1 – Statewide Strategic Plan for Higher Education Research
Attachment 2 – FY18 Performance Measure Report
Attachment 3 – FY18 Research Activity Report
Attachment 4 – FY18 Infrastructure Summary Report
Attachment 5 – FY18 Undergraduate Research Report
Attachment 6 – FY18 Idaho Conference on Undergraduate Research
Attachment 7 – HERC FY19 Budget Allocation
Attachment 8 – FY19 IGEM Fund Summaries
Attachment 9 – 2018 CAES Annual Report
Attachment 10 – Draft presentation to the Board

STAFF COMMENTS AND RECOMMENDATIONS

In addition to the responsibility for recommendations to the Board on the Board's Higher Education Research Strategic plan, HERC is responsible for distributing approximately $4.2M in funds used for the mission of HERC and to incentivize industry and institution research partnerships. Attachment 2 is the October 2018 performance measure report, Attachment 3, is the research institutions' annual research activity reports, Attachment 4 summarizes the infrastructure funding in FY18, Attachment 5 is the institutions' report on undergraduate research, Attachment 6 is the report on the Idaho Conference on Undergraduate Research, Attachment 7 outlines HERC's FY19 budget allocation, and Attachment 8 are summaries of the projects funded by HERC in FY19. Attachment 9 is the annual report for CAES.

The strategic plan is monitored annually and updated as needed based on the work of HERC and direction from the Board. HERC uses a competitive process for distributing funds from the Incubation Fund category and the HERC IGEM Fund category. All proposals that are considered must be in alignment with the Board's Higher Education Research Strategic Plan.

BOARD ACTION

This item is for informational purposes only.

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HIGHER EDUCATION RESEARCH STRATEGIC PLAN

(2017-2022)

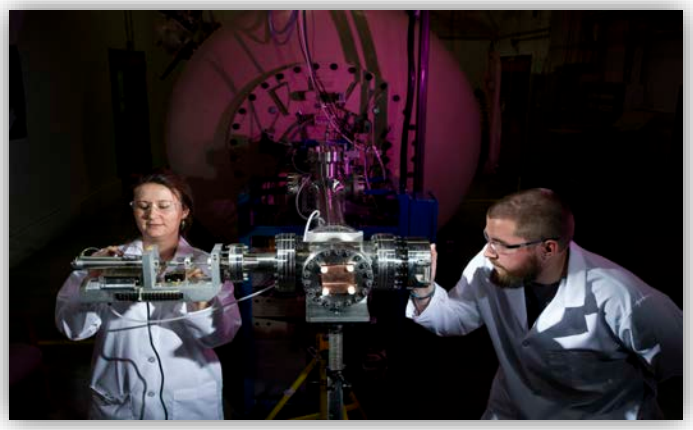
Submitted by: Higher Education Research Council

State Board of Education Approved December 2016

EXECUTIVE SUMMARY

Research is being increasingly acknowledged by industry, government and education as a key factor in the future economic vitality of Idaho. The universities and colleges of Idaho's system of higher education understand the need for greater collaboration in order to be competitive in today's global environment. Recognizing the need to focus on and emphasize existing strengths and opportunities in Idaho's research community, the vice presidents for research and economic development developed the following statewide strategic plan for research to ensure the greatest potential for achieving a vital and sustainable research base for Idaho. The strategic plan identifies the key research areas (basic, translational and clinical) that will become the focal points for research and economic development through partnering among academia, industry and government in science, technology, and creative activity.

Research is fundamental to the mission of a university due to its role in knowledge discovery and in providing new ideas for technology commercialization via patents, copyright, licenses and startup companies. University faculty who engage in research and creative activity are at the leading edge of their respective fields. Research also enhances the national reputation of the faculty and the universities. These faculty and their vibrant research programs attract the best graduate and undergraduate students by providing unique cutting-edge learning experiences in their research laboratories, studios, field sites and classrooms. On the most basic level, and also bolstered through collaborative, interdisciplinary and interprofessional research, such activities strengthen a university's primary product — innovative, well-educated students ready to enter a competitive workforce.



Research is the foundation of a university's economic development role. The influx of research dollars from external grants and contracts creates new jobs at the university, along with the attendant purchases of supplies, services, materials and equipment. The results of the research are new knowledge,

new ideas, and new processes, which lead to patents, startup companies, more efficient businesses as well as a highly trained workforce prepared to tackle 21st century challenges.

Idaho's research universities have strengths and opportunities for economic development in 1) Energy Systems, 2) Natural Resource Utilization and Conservation, 3) Biomedical and Healthcare Sciences, 4) Novel Materials and 5) Systems Engineering and Cybersecurity.

By focusing collaborative efforts in these areas, the research universities will expand research success by:

- Helping Idaho institutions focus on their research strengths;
- Strengthening collaboration among Idaho institutions;
- Creating research and development opportunities that build relationships between universities and the private sector;
- Contributing to the economic development of the State of Idaho;
- Enhancing learning and professional development through research and scholarly activity – also by promoting interdisciplinary and inter-professional research; and
- Building and improving the research infrastructure of Idaho universities to meet current and future research needs.

This statewide Strategic Research Plan for Idaho Higher Education is a tool for identifying and attaining quantifiable goals for research and economic growth and success in Idaho. The plan will be reviewed and updated annually as needed amid the fast-changing pace of research discovery.

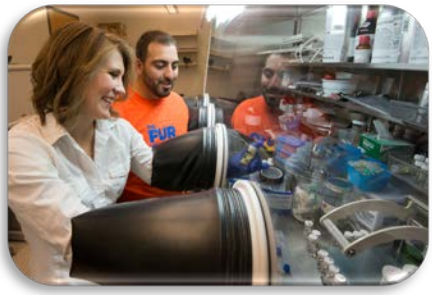
VISION

Idaho's public universities will be a catalyst and engine to spur creation of new knowledge, technologies, products and industries that lead to advances and opportunities for economic growth and enhance the quality of life in Idaho and the nation.

MISSION

The research mission for Idaho's universities is to develop a sustainable resource base by:

- Identifying, recruiting and retaining top faculty with expertise in key research areas;
- Building research infrastructure including facilities, instrumentation, connectivity and database systems to support an expanding statewide and national research platform;
- Attracting top-tier students to Idaho universities at the undergraduate and graduate levels and providing outstanding education and research opportunities that will prepare them to excel in future careers;
- Raising awareness among state, national and international constituencies about the research excellence and capabilities of Idaho's universities by developing and implementing targeted outreach, programs and policies; and
- Collaborating with external public, private, state and national entities to further the shared research agenda for the state, thereby promoting economic and workforce development and addressing the needs and challenges of the state, region and nation.



GOALS AND OBJECTIVES

Goal 1: Increase research at, and collaboration among, Idaho universities and colleges to advance research strengths and opportunities pertaining to critical issues in Idaho, while also providing a vision for national and global impact.

Objective 1.A: Ensure growth and sustainability of public university research efforts.

Performance Measure 1.A.1: Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.
Benchmark: 10% increase per year.

Objective 1.B: Ensure the growth and sustainability of the existing collaborative research at the Center for Advanced Energy Studies (CAES).

Performance Measure 1.B.1: Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.
Benchmark: 10% increase per year.

Objective 1.C: Expand joint research ventures among the state universities.

Performance Measure 1.C.1: Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).
Benchmark: 50% increase per year.

Performance Measure 1.C.2: Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction). Benchmark: 30% increase per year.

Performance Measure 1.C.3: Establish/fund at least one HERC-directed research project per year which collaborates with one other Idaho university that directly addresses issues of particular importance to the State of Idaho.
Benchmark: 1 per year

Goal 2: Create research and development opportunities that strengthen the relationship between state universities and the private sector.

Objective 2.A: Increase the number of sponsored projects involving the private sector.

Performance Measure 2.A.1: Number of new sponsored projects involving the private sector.
Benchmark: 50% increase per year.

Goal 3: Contribute to the economic development of the State of Idaho.

Objective 3.A: Increase the amount of university-generated intellectual property introduced into the marketplace.

Performance Measure 3.A.1: Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).
Benchmark: 15% increase per year.

Performance Measure 3.A.2: Number of invention disclosures (including biomic varieties).
Benchmark: 1 for every $2M of research expenditures.

Performance Measure: 3.A.3: Amount of licensing revenues.
Benchmark: 10% increase per year.

Performance Measure: 3.A.4: Number of startup companies.
Benchmark: 10% increase per year.

Goal 4: Enhance learning and professional development through research and scholarly activity.

Objective 4.A: Increase the number of university and college students and staff involved in sponsored project activities.

Performance Measure 4.A.1: Number of undergraduate and graduate students paid from sponsored projects.
Benchmark: 20% increase per year.

Performance Measure 4.A.2: Percentage of baccalaureate students who had a research experience.
Benchmark: 20% increase per year.

Performance Measure 4.A.3: Number of faculty and staff paid from sponsored projects.
Benchmark: 20% increase per year.

RESEARCH OPPORTUNITIES

Idaho's research universities have developed statewide strengths in strategic research areas that have great potential to drive future economic growth and success. The criteria used to select these areas include: number of faculty and qualifications; peer-reviewed publications and impact; infrastructure (facilities, equipment, information technology, staff); external grant and contract funding; academic programs; student involvement; potential benefit to the State of Idaho; and technology transfer activity, including patents, licenses, and startup companies. By focusing collective research efforts and resources in these areas, the universities will be on the most efficient and effective route to research success and state-wide economic development. These high impact areas include 1) Energy Systems, 2) Natural Resource Utilization and Conservation, 3) Biomedical and Healthcare Sciences, 4) Novel Materials, and 5) Systems Engineering and Cybersecurity.

Energy Systems: Energy is a critical driver of any economy. The projected increases in the population of the world and increases in the standard of living will produce severe strains on the ability to meet the demands of the next few decades. In addition, finite reserves of fossil fuels and pollution from their combustion requires that alternative sources of energy production be developed. The combination of natural resources in Idaho and presence of the Idaho National Laboratory makes energy a natural area of emphasis. Indeed, the three universities with research capabilities already have extensive research projects in this area. The Center for Advanced Energy Studies (CAES) is an example of the significant investment the three Idaho universities, the University of Wyoming, and the Idaho National Laboratory have made to develop expertise in nuclear science and engineering, materials science and engineering, energy systems design and analysis, fossil carbon conversion, geological systems and applications, energy policy and cybersecurity, and environmental and resource sustainability. Further growth in these areas not only takes advantage of the strong base but strongly supports a positive economic impact through new markets for new product development

Natural Resource Utilization and Conservation: In the broad field of natural resource utilization and conservation, Idaho's universities have expertise in water resources, wildfire management and restoration, agriculture, forestry, recreation, and geophysics and geochemical detection, geographical information systems, and monitoring of groundwater pollutants. For example, university geologists, ecologists, and policy experts are collaborating on broad-ranging research projects that examine and predict the impact of climate change on Idaho's water resources. As water is essential to agriculture, recreation, the ecosystem, and human health, the universities have research strength in an area of tremendous societal and economic impact. Agriculture remains an important part of the economy of Idaho. Development of new biomic varieties with improved resistance to disease and climate change remain an area of importance as does the development of new feeds for domestic fish production. The often competing demands for preservation and exploitation put on the environment require understanding of the various ecosystems in the state and region as well as societal, human health, and

economic impacts of policy decisions. Recent national research imperatives, as particularly captured in National Science Foundation's Innovation at the Nexus of Food, Energy, and Water Systems (INFEWS) foundation-wide program and the Department of Energy's report Water-Energy Nexus: Challenges and Opportunities increasingly require multi-sectoral, multi-disciplinary approaches to problems in natural resource utilization and conservation. The depth and breadth of relevant research expertise in the biophysical, rural health and social science fields within Idaho's universities underscores an opportunity that a national emphasis on food, energy, and water security provides. Provided that enhanced coordination and collaboration between Idaho's universities can be successfully executed, we are particularly well-placed to exhibit national and international leadership at the nexus of food, energy, water system research. The future economic success of the state will rely on a deep understanding of these processes.

Biomedical and Healthcare Sciences: Idaho's universities have well-established research programs in selected areas of biological and biomedical sciences. University microbiologists and informatics experts, for example, study real-time change in pathogenic microorganisms that enable them to become resistant to drugs and chemical toxins thus resulting in worsening human disease and mortality rates. These effects are not restricted to humans, domestic and wild animals as well as food plants and trees are experiencing the same phenomena. Also, weeds are becoming resistant to herbicides. These phenomena are having a significant negative impact on Idaho's agriculture and forests. Further stress is being put on these important commercial sectors through climate variability. Research in these areas is critical for preserving important economic sectors of Idaho's economy while addressing future global needs.

The public health infrastructure in rural Idaho is not well understood but is potentially the most fragile aspect of the state's health care system. The rural environment, especially typical in Idaho where agriculture, manufacturing, and fishing are important or dominant parts of the economy, presents extraordinary threats to health. Agriculture brings the use of pesticides and herbicides as well as heavy and potentially dangerous machinery. Manufacturing – depending on the type – is a consistently hazardous industry, and employees involved in fishing and forestry are at much higher risks of trauma. Healthcare and in particular a focus on rural health, provides significant opportunities for economic development in Idaho. Partnerships with private entities in the healthcare industry, funding though the National Institutes of Health and other federal agencies utilize the natural laboratory of Idaho's rural population. Idaho's universities' contributions towards this emerging area of scholarship will add to the global competitiveness of the United States and the State.

Novel Materials: The global materials industry is worth an estimated $550 billion, conservatively. Materials revolutionize our lives by offering advanced performance and new possibilities for design and usage. For example, the market for biocompatible materials has grown from a few to $60B in the past decade. Market size is growing for materials in emerging areas such photonic materials, electronic and dielectric materials, functional coatings, and green materials. Materials research in Idaho is conducted by a wide range of scientists in diverse fields. Across the state, faculty members in Biology, Chemistry, Geosciences, Physics, Electrical Engineering, Mechanical Engineering ,

Nuclear Engineering and Materials Science and Engineering conduct research on improving and developing new materials. Current materials researchers in Idaho cover a broad spectrum of specializations, including semiconductor device reliability, microelectronic packaging, shape memory alloys, DNA machinery, environmental degradation, materials for extreme environments, biomaterials and bio-machinery, materials characterization, and materials modeling. Nanoscale materials and devices, functional materials and their uses and materials for energy applications are a focus of research throughout the state. These areas of research are highly synergistic with local industries and the Idaho National Laboratory (INL). Access to materials characterization equipment and processing laboratories has resulted in collaborations with small businesses and start-up companies.

Systems Engineering and Cybersecurity: Device control , information management, and cybersecurity are an essential part of 21st century life and, therefore, are an important part of educational requirements. For instance, large amounts of sensitive data are collected, processed, and stored electronically but must be accessed and moved in order to have any impact. In fact, many systems are computer controlled through networks. These include such things as the electric transmission grid and transportation in major cities. The universities are beginning to develop research expertise in software development and data management lifecycle design and operations and secure and dependable system design and operations. This area provides a significant area of opportunity for positive economic impact in Idaho, partnerships with the Idaho National Laboratory, and in improving the global competitiveness of the United States. There are already a significant number of firms in Idaho whose interests are in software development for device control, information management and processing. In addition, many of the major research projects being undertaken in the region by various state and federal agencies as well as the universities require the handling of significant amounts of data in a secure and dependable fashion. Currently, research funding in the universities from private and governmental sources is limited by the number of qualified personnel. In addition, within Idaho there is a high demand for graduates at all levels in computer science, hence workforce development in these areas should be a matter of urgency.

EXTERNAL FACTORS: IDAHO RESEARCH ADVANTAGESAND CHALLENGES

There are unique advantages and challenges to research in Idaho. This document seeks to provide guidance on building upon the advantages present in Idaho and address the challenges through the goals in this strategic plan.

Research Advantages

The Idaho National Laboratory (INL) and the Center for Advanced Energy Studies: Idaho is fortunate to be home to the Idaho National Laboratory, one of only 17 U.S. Department of Energy national laboratories in the U.S. The INL's unique history and expertise in nuclear energy, environmental sciences and engineering, alternative forms

of energy, and biological and geological sciences and related fields provides an excellent opportunity for research collaboration with Idaho's university faculty in the sciences, engineering, business and other fields.

The Center for Advanced Energy Studies (CAES), established at the request of the U.S. Department of Energy, is a public-private partnership that includes Idaho's research universities (Boise State University, Idaho State University, and the University of Idaho), the University of Wyoming, and the Battelle Energy Alliance (BEA), which manages the INL. The CAES partners work together to create unique educational and research opportunities that blend the talents and capabilities of Idaho's universities and the INL. A 55,000 square-foot research facility in Idaho Falls supports the CAES energy mission with laboratory space and equipment for students, faculty, and INL staff in collaborative research projects. The State of Idaho invests $3M per year in direct support of the three Idaho research universities.

Natural Resources: Idaho's beautiful natural resources are well known to fishermen, hunters, skiers, and other outdoor enthusiasts. Through its rivers, forests, wildlife, geological formations, and rangelands, Idaho itself is a unique natural laboratory for geological, ecological, and forestry studies. Idaho is home to some of the largest tracts of remote wilderness in the lower 48 states. In addition, the proximity of Yellowstone National Park and the Great Salt Lake provide additional one of a kind opportunities for ecology and geology research.

Small Population: Idaho's relatively small population of 1.6 million people enables every group in the state to be included in research surveys, providing more accurate information than a sampling of only some groups.

Intrastate Networks: The existing networks within the state, including agricultural extension services and rural health networks, provide a foundation for collecting research data from across the state, and rapidly implementing new policies and practices as a result of research discoveries.

Research Challenges

The goals set forth in this strategic plan are specifically designed to address challenges in Idaho. These challenges are identified below and include a description of the challenge and the goal from this strategic plan that addresses that specific challenge.

Lack of Coordination Among Universities In Advancing Research and Economic Development (technology transfer): By and large the research universities have not coordinated and shared their technology transfer and economic development activities among themselves. This not only decreases each university's competitiveness at the national and state level but also increases the costs for achieving a particular goal. There is some redundancy in programs, services and infrastructure between the universities. This duplication both limits the success that any one university can achieve and increases the cost.

Historical Competition Between Universities: One of the greatest problems with growing the research and economic development enterprise within the Idaho university arena has been the competitiveness between research universities. This problem existed at all levels within the universities themselves, extended through university administration to the state level, and was even prevalent in the press. While competition between the universities is to be expected when all are competing for a finite pot of money within the state and is even healthy at some level, the level of competition was counterproductive. The real competition that Idaho universities face is other universities in the United States when it comes to research dollars and attracting faculty and students. Economic development is also not a competition between the state universities but rather a competition with other states.

Goal 1 is designed to remedy these two challenges by "increas(ing) research at, and collaboration among Idaho universities and colleges to advance research strengths and opportunities pertaining to critical issues in Idaho, while also providing a vision for national and global impact."

Competition from Other Universities: In research, university faculty competes nationally for grant funds from federal agencies such as the National Science Foundation, Department of Energy, and the Department of Health and Human Services. Many other states' universities are well ahead of Idaho's universities in terms of state funding per student, patent royalty income, endowments, etc., and are able to move ahead at a faster pace, leaving Idaho universities further behind as time goes on.

Goals 1 and 2 are designed to make Idaho's research universities more competitive nationally and globally through collaboration with each other and by "(strengthening) the relationship between state universities and the private sector."

University Culture: Each of Idaho's research universities aspires to greater levels of achievement in research and creative activity, yet many faculty at each of the universities are not fully engaged on a national level in their respective fields. This is changing for the better under new leadership and with new research-active faculty hires at each institution, but these cultural differences remain, resulting in discomfort with change aimed at making the universities more nationally competitive.

While Goal 1 urges the researchers at Idaho's universities to keep a national and global vision for their research, Goal 4 aims to enhance the research capabilities of faculty by "(enhancing) learning and professional development."

Private Sector Support: Idaho has very little high-technology industry within its borders. This reduces the potential for developing an applied research initiative within the universities that, in many states, provides one important arm of economic development and technology transfer. This also means that it is much harder to develop those private/public partnerships that provide the universities with additional capital to construct research are technology transfer facilities.

The private sector plays a critical role in research. Goal 2 states that we will "create research and development opportunities that strengthen the relationship between state universities and the private sector."

Fragmented Economic Development Initiatives: There are seemingly too many economic development initiatives in Idaho and they are not well coordinated. It is imperative that state, university, and community initiatives work together toward common and agreed to goals. As it is, little progress is being made towards developing an economic strategy for the state that includes the research universities and little money has been secured to drive the economic development process. In fact, it is not uncommon to find that different entities in Idaho are competing against each other.

Positive economic impact is the result of well-organized and collaborative research. It requires strategic planning and execution. Goal 3 indicates that Idaho's research universities focus on "(contributing) to the positive economic impact of the State of Idaho."

Conclusion

This statewide Strategic Research Plan for Idaho Higher Education provides a framework to mitigate these external challenges and help Idaho institutions continue to focus on their research strengths. Overcoming the challenges discussed in this document will require enhanced cooperation between the functional groups at each Idaho university, fueled by a desire to work together towards the common goal of improving Idaho's economy for future generations.

Performance Measure	FY 2014	FY 2015	FY 2016	FY 2017	FY2018	Benchmark
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$142,771,851	$146,699,825	$154,989,123	$163,093,485	Not yet available	10% annual increase
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$13,545,198	$10,116,040	$8,561,218	$9,489,612	Not yet available	10% annual increase
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	77	69	92	119	100	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	53	42	58	70	76	30% annual increase
Number of new sponsored projects involving the private sector.	183	133	165	163	172	50% annual increase
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	34	50	44	33	29	15% annual increase
Number of invention disclosures (including plant varieties)	47	29	40	38	45	1 for every $2M of research expenditures
Amount of licensing revenues.	$1,192,007	$441,071	$724,316	$1,271,819	$ 1,869,718	10% annual increase
Number of startup companies.	0	0	8	1	1	10% annual increase
Number of undergraduate students paid from sponsored projects.	1,383	1,699	1,683	1,811	2,100	20% annual increase
Number of graduate students paid from sponsored projects.	860	648	636	716	656	20% annual increase
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.	UI: 58.8%, BSU: Not Reported, ISU: Not Reported	UI: 57.85%, BSU: Not Reported, ISU: 71%	UI: 60.4%, BSU: Not Reported, ISU: 13%	UI: 65.95%, BSU: Not Reported, ISU: 12.1%	UI: 62.71%, BSU: Not Reported, ISU: 19.56%	20% annual increase
Number of faculty and staff paid from sponsored projects.	2,050	2,375	2,272	2,383	2,418	20% annual increase
K-20 Statewide Stratgic Plan Performance Measures						
Percentage of students participating in undergraduate research.	N/A	N/A	48%	51%	UI: 61.07%, BSU: 37% ISU: 45%	30%
Total amount of research expenditures	$73,726,315	$101,830,918	$102,430,041	$98,655,844	$96,791,359	
Institution expenditures from competitive Federally funded grants	$81,951,549	$106,047,448	$104,850,624	$104,822,280	$109,419,029	$112M annually
Institution expenditures from competitive industry funded grants	$7,748,543	$7,389,079	$8,732,410	$9,681,210	$62,830,537	$7.2M annually
Measure of production of intellectual property:						
Number of startups	0	0	8	1	1	10% annual increase
Number of patents	13	10	18	4	1	10% annual increase
Number of student internships	2,109	2,090	2,294	2,186	2,191	

Performance Measure	FY 2014	FY 2015	FY 2016	FY2017	FY2018	Benchmark
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$95,593,851	$97,492,825	$102,457,123	$109,537,485	$111,589,983	10% annual increase
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$4,613,198	$3,940,040	$3,694,218	$4,128,612	$3,926,015	10% annual increase
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	24	25	18	30	23	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	10	14	12	12	14	30% annual increase
Number of new sponsored projects involving the private sector (See Note A below)	53 (a); 15 (b)	45 (a); 12 (b)	47 (a); 18 (b)	47 (a); 19 (b)	47 (a); 19 (b)	50% annual increase
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	7	11	13	5	5	15% annual increase
Number of invention disclosures (including plant varieties)	18	14	18	21	24	1 for every $2M of research expenditures
Amount of licensing revenues.	$1,156,407	$419,596	$570,469	$1,232,588	$1,844,878	10% annual increase
Number of startup companies.	0	0	0	0	0	10% annual increase
Number of undergraduate students paid from sponsored projects.	489	575	697	696	765	20% annual increase
Number of graduate students paid from sponsored projects.	488	574	463	544	500	20% annual increase
Number of baccalaureate students who graduated in STEM disciplines and had a research experience (Note B)	411/699	361/624	366/606	403/611	360/574	
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience (Note B)	58.80%	57.85%	60.40%	65.95%	62.71%	20% annual increase
Number of faculty and staff paid from sponsored projects.	1,153	1,175	1,231	1,269	1,263	20% annual increase
K-20 Statewide Stratgic Plan Performance Measures						
Percentage of students participating in internships (Note C)	1,326	764	6.64% (909 of 13700)	6.42% (879 of 13700)	5.99% (812 of 13,553)	30%

Number of students participating in undergraduate research (Note B)	1124 / 1886	1079 / 1765	992 / 1687	1001 / 1550	885/1449	
Percentage of students participating in undergraduate research (Note B)	59.60%	61.13%	58.80%	64.58%	61.07%	30%
Total amount of research expenditures	$56,385,826	$54,955,421	$ 55,893,584	$ 57,114,745	$ 57,082,023	20% increase by 2021
Institution expenditures from competitive Federally funded grants	$64,567,276	$63,565,943	$63,328,954	$64,092,411	$65,309,507	$112M annually
Institution expenditures from competitive industry funded grants (Note A)	$1,452,711 (a); $4,221,605 (b)	$1,527,156 (a); $3,895,740 (b)	$1,825,722 (a); $3,474,729 (b)	$1,804,800 (a); $2,996,496 (b)	$1,758,830 (a); $3,466,925 (b)	$7.2M annually
Measure of production of intellectual property:						
Number of startups	0	0	0	0	0	10% annual increase
Number of patents	7	7	3	1	1	10% annual increase
Number of invention disclosures (including plant varieties)	18	14	18	21	24	10% annual increase

Performance Measure Explanatory Notes:

Note A - Activity with private sector/industry - (a) is funding from private sector, and (b) is funding from private sector, federal flow through.

Note B - Due to process improvement, previous years have been corrected to reflect correct figures.

Note C - In FY13 to FY15 we had to report the number of internships. Starting in FY16 we had to report % of internships so provided the number and % for FY16

Performance Measure	FY 2015	FY 2016	FY2017	FY2018	Benchmark
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$31.341 Million	$32.085 Million	$34.992 Million	Not Available	10% annual increase
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$2.090 Million	$1.745 Million	$2.071 Million	Not Available	10% annual increase
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction). [1]	26	44	60	50	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction). [2]	15	19	26	27	30% annual increase
Number of new sponsored projects involving the private sector. [3]	a) 10; b) 12	a) 22; b) 13	a) 17 b) 16	a) 8 b) 20	50% annual increase
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	38	29	28	24	15% annual increase
Number of invention disclosures (including plant varieties)	15	16	14	14	1 for every $2M of research expenditures
Amount of licensing revenues. *	$21,475	$53,847	$39,231	$24,840	10% annual increase
Number of startup companies.	0	5	0	1	10% annual increase
Number of undergraduate students paid from sponsored projects.	807	836	946	1,136	20% annual increase
Number of graduate students paid from sponsored projects.**					20% annual increase
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.**					20% annual increase
Number of faculty and staff paid from sponsored projects.	676	784	867	963	20% annual increase
K-20 Statewide Stratgic Plan Performance Measures					
Percentage of students participating in undergraduate research.	29.40%	35.2% (490 out of 1388)	37.4% (567 out of 1517)	37% (494 out of 1334)	30%
Total amount of research expenditures	$ 20,613,352.75	$ 18,865,799.18	$ 21,094,099.17	$ 27,718,836.71	20% increase by 2021
Institution expenditures from competitive Federally funded grants	$ 21,042,683.81	$ 19,306,479.00	$ 21,172,737.94	$ 26,311,205.03	$112M annually
Institution expenditures from competitive industry funded grants	a. $266,467.06 b. $1,699,715.80	a. $562,457.27 b. $1,458,502.01	a. $681,146.82 b. $2,258,431.54	a. $674,881.78 b. $3,162,026.73	$7.2M annually
Measure of production of intellectual property:					
Number of startups	0	5	0	1	10% annual increase
Number of patents	3	4	3	3	10% annual increase
Number of disclosures	15	16	14	14	10% annual increase
Number of internships	438	489	394	446	

[1] Represents the number of full proposal submissions that involved a financial relationship with another Idaho institution of higher education.
[2] Represents the number of new awards that involved a financial relationship with another Idaho institution of higher education.
[3] Represents the number of new awards that involved a financial relationship with the private sector.
[4] Internship information is based on estimates by academic year (e.g., FY09=Academic year Summer 2008 through Spring 2009).

**Undergraduate and Graduate student totals have been combined into one line as BSU does not have the ability to break this information out.

Performance Measure	FY 2015	FY 2016	FY17	FY18	Benchmark
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$17,866,000	$20,447,000	$18,564,000	available after 1/15/19	10% annual increase
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$4,086,000	$3,122,000	$3,290,000	available after 1/15/19	10% annual increase
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	18	30	29	27	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	13	27	32	35	30% annual increase
Number of new sponsored projects involving the private sector.	54	65	65	78	50% annual increase
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	1	2	0	No new licenses to ISU-owned patents were entered into in FY18	15% annual increase
Number of invention disclosures (including plant varieties)	0	6	3	7 Disclosures were received	1 for every $2M of research expenditures
Amount of licensing revenues.	0	$100,000	0	$0.00	10% annual increase
Number of startup companies.	0	3	1	No new startups based on ISU Technology were founded in FY18	10% annual increase

Number of undergraduate students paid from sponsored projects.	317	150	169	199	20% annual increase
Number of graduate students paid from sponsored projects.	74	173	172	156	20% annual increase
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.	71%	13.00%	12.10%	19.56%	20% annual increase
Number of faculty and staff paid from sponsored projects.	524	257	247	192	20% annual increase
# of students participating in internships	888	896	913	933	
K-20 Statewide Stratgic Plan Performance Measures					
Percentage of students participating in undergraduate research.	41%	45%	45%	45%	30%
Total amount of research expenditures	$13,885,952	$14,378,588	$12,785,596	$11,990,499	20% increase by 2021
Institution expenditures from competitive Federally funded grants	$21,438,821	$22,215,191	$19,557,131	$17,798,317	$112M annually
Institution expenditures from competitive industry funded grants	N/A	$1,411,000	$1,940,336	$1,911,606	$7.2M annually
Measure of production of intellectual property:		N/A		0	
Number of startups	0	3	1	No new startups based on ISU Technology were founded in FY18	10% annual increase
Number of patents	0	11	0 issued 2 applications filed	1 patent issued, and 4 new applications were filed.	10% annual increase
Number of disclosures		6	3	7 disclosures were received	10% annual increase
% of students participating in internships			7.70%	7.80%	

Boise State University

Sponsored Project Activity Report FY2018

Awards for the Period July 1, 2017 through June 30, 2018

Activity Type	Federal	State	Industry	Other	Total	% of Grand Total
Instruction:						
Sponsored Programs	$ 3,571,816	$ 1,898,067	$ -	$ 43,100	$ 5,512,983	
State Instruction Appropriations	$ -	$ 700,000	$ -	$ -	$ 700,000	
Subtotal Instruction	$ 3,571,816	$ 2,598,067	$ -	$ 43,100	$ 6,212,983	11.09%
Research:						
Sponsored Programs	$ 32,710,197	$ 1,760,510	$ 720,180	$ 889,491	$ 36,080,378	
State Research Appropriations	$ -	$ 778,870	$ -	$ -	$ 778,870	
Subtotal Research	$ 32,710,197	$ 2,539,380	$ 720,180	$ 889,491	$ 36,859,248	65.80%
Other Sponsored Activities:						
Sponsored Programs	$ 8,102,449	$ 2,067,999	$ 27,545	$ 2,743,568	$ 12,941,561	
State Other Sponsored Activities Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal Other Sponsored Activities	$ 8,102,449	$ 2,067,999	$ 27,545	$ 2,743,568	$ 12,941,561	23.10%
Grand Totals	**$ 44,384,462**	**$ 7,205,446**	**$ 747,725**	**$ 3,676,159**	**$ 56,013,792**	
Percent of Grand Total	***79.24%***	***12.86%***	***1.33%***	***6.56%***	***100%***	***100%***

Expenditures for the Period July 1, 2017 through June 30, 2018

Activity Type	Federal	State	Industry	Other	Totals	% of Grand Total
Instruction:						
Sponsored Programs	$ 4,483,060.77	$ 922,020.72	$ 3,000.00	$ 66,398.35	$ 5,474,479.84	
State Instruction Appropriations	$ -	$ 717,227.37	$ -	$ -	$ 717,227.37	
Subtotal Instruction	$ 4,483,060.77	$ 1,639,248.09	$ 3,000.00	$ 66,398.35	$ 6,191,707.21	13.38%
Research:						
Sponsored Programs	$ 24,780,469.40	$ 1,379,339.60	$ 641,205.17	$ 917,822.54	$ 27,718,836.71	
State Research Appropriations	$ -	$ 761,426.21	$ -	$ -	$ 761,426.21	
Subtotal Research	$ 24,780,469.40	$ 2,140,765.81	$ 641,205.17	$ 917,822.54	$ 28,480,262.92	61.54%
Other Sponsored Activities:						
Sponsored Programs	$ 8,209,036.05	$ 2,207,450.36	$ 30,676.61	$ 1,159,676.74	$ 11,606,839.76	
State Other Sponsored Activities Appropriations	$ -	$ (8.03)	$ -	$ -	$ (8.03)	
Subtotal Other Sponsored Activities	$ 8,209,036.05	$ 2,207,442.33	$ 30,676.61	$ 1,159,676.74	$ 11,606,831.73	25.08%
Grand Totals	**$ 37,472,566.22**	**$ 5,987,456.23**	**$ 674,881.78**	**$ 2,143,897.63**	**$ 46,278,801.86**	
Percent of Grand Total	***80.97%***	***12.94%***	***1.46%***	***4.63%***	***100%***	***100%***

IDAHO STATE UNIVERSITY

8/24/2018

SPONSORED PROJECT EXPENDITURE REPORT
FY2018

AMOUNT PER FUNDING TYPE

Expenditures for the Period July 1, 2017 through June 30, 2018

	Federal	State	Industry	Other	Totals	
Research	$10,080,598	$749,774	$973,054	$187,073	$11,990,499	53%
Training and Instruction	$6,582,061	$1,265,245	$348,573	$39,665	$8,235,544	37%
Other/Public Service	$1,135,659	$419,722	$589,978	$8,012	$2,153,371	10%
Totals	$17,798,317	$2,434,742	$1,911,606	$234,750	$22,379,415	
Percent of Total	80%	10%	9%	1%	100%	100%

Idaho State University
Office for Research
Award Breakdown by Funding Agency Type and Project Type
July 1, 2017 through June 30, 2018

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	3,441,775	2,426,330	3,641,093	534,357	10,043,555	57%
Training and Instruction	2,130,860	1,913,122	912,636	257,737	5,214,355	30%
Other/Public Service	425,885	1,184,769	306,391	310,254	2,227,299	13%
Totals	5,998,520	5,524,221	4,860,120	1,102,348	17,485,209	100%
Percent of Total	34%	32%	28%	6%	100%	

File Name: ISU OR Annual Awards FY18_rev

University of Idaho - FY2018 Research Activity Report

Awards for the Period July 1, 2017 through June 30, 2018

	Federal	State of Idaho	Industry	Other	Total	% of Grand Total	% of Sponsor Total
Instruction:							
Sponsored Programs	$ 2,570,952.95	$ 400.00	$ 43,000.00	$ 65,000.00	$ 2,679,352.95		**3%**
	$ 2,570,952.95	$ 400.00	$ 43,000.00	$ 65,000.00	$ 2,679,352.95	**2%**	
Research:							
Sponsored Programs	$ 52,072,040.46	$ 2,221,969.79	$ 1,404,464.21	$ 3,871,661.18	$ 59,570,135.64		**73%**
Federal Land Grant Appropriations (FFY18)	2,734,471.00				2,734,471.00		
State Research/Endowment Appropriations		22,332,524.35			22,332,524.35		
Subtotal Research:	$ 54,806,511.46	$ 24,554,494.14	$ 1,404,464.21	$ 3,871,661.18	$ 84,637,130.99	**70%**	
Public Service:							
Sponsored Programs	$ 16,060,226.50	$ 2,119,006.89	$ 20,000.00	$ 1,284,054.10	$ 19,483,287.49		**24%**
Federal Land Grant Appropriations (FFY18)	2,900,260.00				2,900,260.00		
State Extension Appropriations		11,358,275.65			11,358,275.65		
Subtotal Public Service:	$ 18,960,486.50	$ 13,477,282.54	$ 20,000.00	$ 1,284,054.10	$ 33,741,823.14	**28%**	
Construction:							
Sponsored Programs	-	-	-	-	-	**0%**	**0%**
Total Sponsored Programs Funding	**$ 70,703,219.91**	**$ 4,341,376.68**	**$ 1,467,464.21**	**$ 5,220,715.28**	**$ 81,732,776.08**		
Percent of Total Sponsored Programs	***87%***	***5%***	***2%***	***6%***	***100%***		***100%***
Grand Total of All Funding Per Category	**$ 76,337,950.91**	**$ 38,032,176.68**	**$ 1,467,464.21**	**$ 5,220,715.28**	**$ 121,058,307.08**		
Percent of All Funding	***63%***	***32%***	***1%***	***4%***	***100%***	***100%***	

Expenditures for the Period July 1, 2017 through June 30, 2018 (includes accruals)

	Federal	State of Idaho	Industry	Other	Institutional	Total	% of Grand Total	% of Sponsor Total
Instruction:								
Sponsored Programs	$ 2,464,809.81	$ 295,233.40	$ 62,165.81	$ 335,294.50	$ 576,230.10	$ 3,733,733.62		**4%**
	$ 2,464,809.81	$ 295,233.40	$ 62,165.81	$ 335,294.50	$ 576,230.10	$ 3,733,733.62	**2%**	
Research:								
Sponsored Programs	$ 48,793,081.30	$ 2,411,944.95	$ 1,908,483.37	$ 3,888,369.30	$ 8,481,054.49	$ 65,482,933.41		**72%**
Federal Land Grant Appropriations (D11315,D11316	2,378,944.32					2,378,944.32		
State Research Appropriations (D11311,D51346,D51360)		22,338,631.94				22,338,631.94		
State Endowment/Other Appropriations		6,532,367.82				6,532,367.82		
Other Sources	-		-	6,042,232.79	8,814,873.06	14,857,105.85		
Subtotal Research:	$ 51,172,025.62	$ 31,282,944.71	$ 1,908,483.37	$ 9,930,602.09	$ 17,295,927.55	$ 111,589,983.34	**74%**	
Public Service:								
Sponsored Programs	$ 15,585,465.77	$ 2,538,779.35	$ -	$ 1,254,176.08	$ 2,750,565.91	$ 22,128,987.11		**24%**
Federal Land Grant Appropriations (D21325)	2,493,632.45					2,493,632.45		
State Extension Appropriations (D1321)		11,399,908.57				11,399,908.57		
Subtotal Public Service:	$ 18,079,098.22	$ 13,938,687.92	$ -	$ 1,254,176.08	$ 2,750,565.91	$ 36,022,528.13	**24%**	
Construction:								
Sponsored Programs	$ -	$ -	$ -	$ -	$ -	$ -	**0%**	**0%**
Total Sponsored Programs Funding	$ 66,843,356.88	$ 5,245,957.70	$ 1,970,649.18	$ 5,477,839.88	$ 11,807,850.50	$ 91,345,654.14		
Percent of Total Sponsored Programs	***73%***	***6%***	***2%***	***6%***	***13%***	***100%***		**100%**
Grand Total of All Funding Per Category	$ 71,715,933.65	$ 45,516,866.03	$ 1,970,649.18	$ 11,520,072.67	$ 20,622,723.56	$ 151,346,245.09		
Percent of All Funding	***47%***	***30%***	***1%***	***8%***	***14%***	***100%***	100%	

Boise State University
FY 2018 INFRASTRUCTURE REPORT SUMMARY

	Total $	Detailed Allocations
Library Support		
Graduate Research Assistantships / Research Associates	$100,000	Graduate College / Chemistry Graduate Assistants
Post-Doctoral Fellows		
Technician Support		
Maintenance Contracts		
Research Equipment / Project Support		
Competitvely Awarded Summer Research Support		
Start-Up Funds for New Hires	$15,700	Computer Science Incubation Funds / Gaby Dagher
Incentives to Reward Faculty for Research Achievements		
Other	$135,587	Salary /Fringe for Tech Transfer Director / Patent officer
Total Allocation	$251,287	

	Detailed Allocations
Publications in Refereed Journals	
Presenations at Professional Meetings and Conferences	
Grants Received as a Result	
Grants Pending	
Student Participation	
Faculty Participation	
Other Participation	
Patents Awarded	
Patents Pending	

	Total $	Detailed Allocations
Library Support		n/a
Graduate Research Assistantships / Research Associates		6 graduate students (CAMAS)
Post-Doctoral Fellows		1 (CAMAS)
Technician Support		n/a
Maintenance Contracts		n/a
Research Equipment	$8,900	Chiller for Microscopy Lab (EAMES complex)
Competitvely Awarded Summer Research Support		n/a
Start-Up Funds for New Hires		n/a
Incentives to Reward Faculty for Research Achievements		n/a
Other	$241,100	The HRC funds allocated to the ISU Research Data Center (RDC) were used to purchase and maintain the servers, virtual machines, and high performance computer cluster located in the RDC facility. This includes the physical racks, security cameras, security detection devices, and facility maintenance. The RDC is a univesity wide facility supporting all researchers at ISU Chiller for EAMES Microscopy Lab. Relocate CAMAS to EAMES.
Total Allocation	$250,000	

Publications in Refereed Journals	N/A
Presenations at Professional Meetings and Conferences	N/A
Grants Received as a Result	N/A
Grants Pending	N/A
Student Participation	12 - 4 undergrads and 6 graduate students 2 graduate affiliates
Faculty Participation	2 visiting Research Professors (STEM)
Other Participation	
Patents Awarded	N/A
Patents Pending	N/A

INFRASTRUCTURE RESEARCH AND IMPACT FORM

Reporting Unit: Infrastructure expenses FY 2018 Date: Fiscal year 2018
Please provide the information requested in the appropriate spaces below. The intent is to obtain correct data on the direct or partially direct impact of your usage of infrastructure research funds.

Finds received for Fiscal Year: FY2018

Amount allocated to your unit: $250,000 for: Research Data Center upgrade and CAMAS

Educational Impact

Number of undergrad students involved	Number of graduate students involved	Number of postdoctoral students involved
4	8	1

Research Impact - Grants

Number of Grants Pending	Dollar Amount0 Pending	Number of grants received	Dollar amount received
0	$ 0	0	$ 0

Research Impact – Publications

Number of publications	Number of manuscripts submitted	Number of papers presented at regional or national meetings
0	0	0

Research Impact – Seminars, collaborations, Presentations

Number of seminars presented at ISU	National or International collaborations developed	Number of public school presentations
Student participation:	Student participation: 12	Student participation:
Faculty Participation: 0	Faculty Participation: 2	Faculty Participation: 0
Other Participation:	Other Participation:	Other Participation:

FY 2018 INFRASTRUCTURE REPORT SUMMARY

	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$48,101	2 graduate assistantships
Post-Doctoral Fellows	$1,959	$1,959 for two postdoctoral scholars to attend conference
Technician Support	$121,098	$30,548 - Glass Blower provides repair and construction services to UI labs; $30,737 - Mass Spectrometry Director provides research support to UI labs; $59,813 - Optical Imaging Director provides research support to UI labs
Maintenance Contracts	$0	
Equipment	$18,425	$9,647 - Equipment to build a pilot scale facility for glucosinate extraction; $8,778 - Security system upgrade at the Hagerman Fish Culture Experiment Station.
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$0	
Other	$78,809	$70,809 - Postdoctoral fellow promoted to faculty working on EPSCoR director's research projects; $8K - Collected and modeled data from Idaho public hearings for creation of public-facing website and curated digital exhibit of oral histories collected from the Gay Rodeos.
Total Allocation	$268,392	

FY 2018 INFRASTRUCTURE REPORT SUMMARY

ATTACHMENT 4

	Detailed Allocations
Publications in Refereed Journals	10
Presenations at Professional Meetings and Conferences	8
Grants Received as a Result	7
Grants Pending	2
Student Participation	5
Faculty Participation	14
Other Participation	19
Patents Awarded	0
Patents Pending	1

NOTE: The glassblower, Mass Spectrometry Core and the Optical Imaging Core provide services to research laboratories, which affects research activities of students, faculty and staff, including publications, presentations, and grants. $8,778 was spent for security system upgrade for the Hagerman Fish Culture Experiment Station that houses UI's Aquaculture Research Institute, Columbia River Intertribal Fish Commission, and US Department of Agriculture's Agricultural Research Service. The 15-year old security technology was acting erratically and was locking and unlocking doors outside of the normal schedule creating security concerns for staff, infrastructure, and equipment. $9,647 was partial support to build a pilot plant to extract biopesticides from plant residues was constructed to provide material for determining efficacy on eradicating nematodes and controlling weeds. $8,000 was provided for two faculty projects. The first project acquired and cleaned data for use with topic modeling to prepare for various data visualizations to be used in a public-facing website. The second project collected oral histories with the Gay Rodeo to create a curated digital exhibit highlighting the points of convergence and divergence in the experiences of LGBTQ+ westerners.

	Total $	Detailed Allocations
Library Support	$26,500	50 Events That Shaped American Indian History : An Encyclopedia of the American Mosaic Ebook $189.00 Acland's DVD Atlas of Human Anatomy (6 DVD set) DVD $314.98 African Americans at Risk: Issues in Education, Health, Community, and Justice Ebook $207.90 American Women Speak: An Encyclopedia and Document Collection of Women's Oratory Ebook $207.90 Analyzing Art, Culture, and Design in th eDigital Age, 1st Edition Ebook $203.50 Atlas of Human Anatomy Ebook $337.46 Atlas of the Human Brain Ebook $300.00 Central Intelligence Agency: An Encyclopedia of Covert Ops, Intelligence Gathering, and Spies Ebook $207.90 Clothing and Fashion: American Fashion from Head to Toe Ebook $456.50 Colour Atlas of Glacial Phenomena Ebook $179.95 Communication Arts Backfile Paper $792.00 Crime and Punishment in America: An Encyclopedia of Trends and Controversies in the Justice System, 1st Ed. Ebook $207.90 Destruction of Memory DVD $348.00 Encyclopedia of Mental Health, 2nd edition EBook $1,663.20 Gale Encyclopedia of Genetic Disorders, 4th Edition Ebook $621.50 Gale Encyclopedia of Nutrition and Food Labels, 1st Edition Ebook $291.50 Gale Encyclopedia of Pregnancy and Childbirth, 1st Edition Ebook $544.50 Gender: Sources, Perspectives, and Methodologies, 1st Edition Ebook $196.90 Great American Mosaic: An Exploration of Diversity in Primary Documents, 1st Edition Ebook $456.50 Gut-Brain Axis, 1st Edition Ebook $250.80 SAGE Encyclopedia of Cancer and Society, 2nd Edition Ebook $680.90 SAGE Encyclopedia of Contemporary Early Childhood Education, 1st Edition Ebook $721.60 Sage Encyclopedia of Economics & Society, 1st Edition Ebook $894.30 SAGE Encyclopedia of Stem Cell Research, 2nd Edition Ebook $721.60 Spanish Empire: A Historical Encyclopedia, 1st Edition Ebook $217.80 Supreme Court Compendium, 6th Edition Ebook $268.40 Tiller's Guide to Indian Country: Economic Profiles of American Indian Reservations Ebook $150.00 Youth Cultures in America, 1st Edition Ebook $55.00 Ebsco - Nature, online $9,256.28 Ebsco - Cell, online $4,688.21 Good Docs - Strong! Lift like a Girl, Streaming, incl. DVD $486.00 New Days Films - The Year We Thought About Love, Streaming $350.00 Tugg Inc. - , The Business of Amateurs, Digital Streaming $300.00 YBP Library Services - Encyclopedia of Constitutional Amendments, E-book $189.00 YBP - Handbook of Attachment: Theory, Research, and Clinical Applications, E-Books $190.00
Graduate Research Assistantships / Research Associates	$7,500	12th Annual Lewis-Clark State College Research Symposium
Post-Doctoral Fellows	$0	
Technician Support	$0	
Maintenance Contracts	$0	
Research Equipment	$24,053	Centrifuge repair, $2,217; Metabolic measuring system (ParvoMedics), $14,000; Dell PowerEdge R730xd server
Competitively Awarded Summer Research Support	$9,000	Monitoring jaguar and the terrestrial wildlife in a tropical wildlife community in Costa Rica; Creating a resource for educator and professionals: Dr. Frederick Sports Leadership Series Podcasts; Increasing student success through a multi-dimensional systems approach; The effects of plyometric training on muscle activation characteristics in post-pubescent adolescent females
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$5,138	Grant-writing incentive stipends: 11
Other	$15,477	Qualitrics subscription; "Nature" article publication costs; AmeriCorps match; postage
Total Allocation	$87,668	

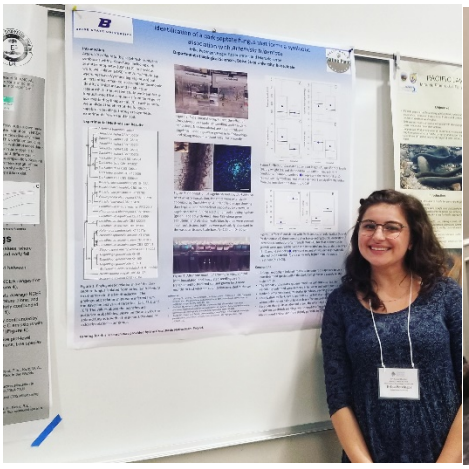
	Detailed Allocations
Publications in Refereed Journals	**Empirical Detection of Induced DNA Mutations:** 1. Addo-Quaye, C., Tuinstra, M., Carraro, N., Weil, C., & Dilkes, B. P. (2018). Whole-Genome Sequence Accuracy Is Improved by Replication in a Population of Mutagenized Sorghum. G3: Genes, Genomes, Genetics, 8(3), 1079–1094. 2. Thapa, R., Carrero-Colón, M., Addo-Quaye, C., Held, J., Dilkes, B., & Hudson, K. A. (2018). New Alleles of FAD3A Lower the Linolenic Acid Content of Soybean Seeds. Crop Science, 58, 713–718.
Presentations at Professional Meetings and Conferences	**Monitoring jaguars:** Wildlife Society, Idaho Chapter meeting in Pocatello, Idaho March 2018. **Characterizing Blm-dependent DNA replication:** Jolee Aeschliman*, Joshua Mundell, Mallory McDermott, Shane Kinzer, Alyssa Copple, Nathan Anderson, Lindsey Riggs, Abbie Olson, Leigh Latta, Mia Levine, Eric Stoffregen. Idaho INBRE Statewide Research Conference, Moscow, ID, July 2018. Poster Presentation. Joshua Mundell*, Mallory McDermott, Shane Kinzer, Jolee Aeschliman*, Alyssa Copple*, Nathan Anderson*, Lindsey Riggs, Abbie Olson, Leigh Latta, Mia Levine, Eric Stoffregen. Naturally derived, Blm-dependent Y chromosome genetic variation affects sex-specific survival in Drosophila melanogaster. Drosophila Research Conference, Philadelphia, PA. April, 2018. Poster Presentation Joshua Mundell*, Shane Kinzer*, Mallory McDermott, Lindsey Riggs, Abbie Olson, Leigh Latta, Mia Levine, Eric Stoffregen. Y chromosome variation in Drosophila melanogaster impacts the function of Blm DNA helicase. Environmental Mutagenesis and Genomics Society Meeting, Raleigh, NC, September 2017. Poster Presentation. **Microbiology:** Kory Parker- Idaho Conference on Undergraduate Research poster presentation. **TRIO Student Support Services:** Influences on Rural Students' College Access and Completion: A Qualitative Study, Council for Education Opportunity national conference. **NSF S-STEM:** June 1, 2018. Erin Cassetto, LaChelle Rosenbaum, Heather Henson-Ramsey, and Elizabeth Martin presented “Work Works! Student Success Through a Co-Curricular Work-Based Learning Model” at the NASPA Closing the Achievement Gap: Student Success in Higher Education Conference in Columbus, OH.

Grants Received as a Result	Amanda Gill, Idaho Community Foundation, Kids College - $5,000; Charles Addo-Quaye, USDA - $29,689; Victoria Boubel, Idaho Community Foundation, infant resuscitation manikins - $4,925; Rebecca Fromdahl, Idaho Futures Fund, expand sample pool for data collection - $15,000; Rebecca Fromdahl, AmeriCorps State grant, "The effects of one-on-one and small group tutoring on academic performance in rural north Idaho K-12" - $236,975; Linda Stricklin, North Idaho College subaward: ICE Healthcare Partnership, Industry Sector; Idaho Department of Labor: Apprenticeship Idaho; Idaho Career and Technical Education, adult retraining - $80,517.
Grants Pending	
Student Participation	INBRE Stoffregen - 7; INBRE Latta - 3; USDA Addo-Quaye - 2: Microbiology - 1; Jaguar Hay - 1; Plyometric training - 6; Research Symposium: XXX
Faculty Participation	**Research symposium (8 total):** Dr. Colin Fehr, Assistant Professor, Movement and Sports Sciences; Dr. Tracy Flynn, Professor, Nursing and Health Sciences; Dr. Nancy Johnston, Assistant Professor of Chemistry; Dr. Brett Morris, Instructor, Business Division; Sydney Parker, Assistant Professor, Nursing; Dr. Susan Steele, Assistant Professor, Movement and Sports Sciences; Dr. Kerensa Allison, Associate Professor, Anthropology; Dr. Rachelle Genthos, Assistant Professor of Psychology. |**Monitoring Jaguar (1 total):** Leslie Hay, Adjunct, Natural Science and Mathematics | **INBRE (2 total):** Dr. Eric Stoffregen, Assistant Professor of Biology; Dr. Leigh Latta, Assistant Professor of Natural Science and Mathematics | **USDA (1 total):** Dr. Charles Addo-Quaye, Assistant Professor of Computer Science | **NSF S-STEM:** Dr. Elizabeth Martin, Assistant Professor, Natural Science and Mathematics; Dr. LaChelle Rosenbaum, Assistant Professor/Division Chair, Social Work; Dr. Heather Henson-Ramsey, Associate Professor/Division Chair, Natural Science and Mathematics; Dr. John Morrison, Assistant Professor, Physics. | **Air quality:** Dr. Nancy Johnston, Assistant Professor, Chemistry | **Nursing:** Victoria Boubel, Instructor/Simulation Lab Coordinator
Other Participation	**USDA:** Sampurna Sattar, Portland State University (PI) | **Research Symposium:** Dr. Matthew Silvers, Whitworth University | **NSF S-STEM:** Erin Cassetto, LC Work Scholars; Julian Ankney, AmeriCorps VISTA | **AmeriCorps:** Rebecca Fromdahl, Director; Barbara Syska, Technical Records Specialist | **Kids College:** Amanda Gill, Development Coordinator | **Workforce Training:** Dr. Linda Stricklin, Director of Workforce Training.
Patents Awarded	
Patents Pending	

Higher Education Research Council Fellowship
Boise State University
Final Report

Academic Year 2017-18

Donna Llewellyn, Executive Director, Institute for STEM & Diversity Initiatives
Catherine Bates, STEM Diversity Coordinator, Institute for STEM & Diversity Initiatives



BOISE STATE UNIVERSITY

Idaho State Board of Education

Introduction

The Institute for STEM & Diversity Initiatives administered the HERC Fellowship at Boise State University for Fall 2017 and Spring 2018. All STEM department chairs were notified of the HERC Research Fellowship application. The application was also disseminated to all STEM undergraduate students. We changed the process this past year to allow for joint faculty and student applications. This change requires students to identify a research faculty to work with and their faculty mentor must nominate them for the fellowship. We had 103 students apply for Fall 2017and Spring 2018 positions. For Fall 2017, 9 students were awarded the HERC fellowship, and 8 students were awarded the fellowship in the Spring semester.

We saw an increase in the number of underrepresented minority HERC fellows to 41% of the awardees and the majority of the recipients were first-time student researchers. HERC fellows presented final research projects at either the Undergraduate Research Conference or the Idaho Conference of Undergraduate Research at Boise State University. One fellow presented her research at the Northwest Scientific Association in Olympia, Washington in April. Another student disseminated his work at the Annual Biophysical Society Meeting. And finally, 10 students attended the Pacific Sociological Association annual conference in Long Beach, CA. Students and faculty mentors are from a variety of disciplines (please see below).

On behalf of the Institute for STEM and Diversity Initiatives, we thank the Higher Education Research Council for their generous support in helping build meaningful high impact practices for our undergraduate students.

HERC Funding:

The Higher Education Research Council provided $55,000 to support undergraduate students in their pursuit of faculty mentor supported undergraduate research experience. Please see table below of how stipends and travel awards were dispersed.

Stipends	**Amount**
Fall 2017 Research Stipends	$27,000
Spring 2018 Research Stipends	$24,000*
Student Travel to Professional Conference	**Amount**
Supplemental travel to National Biomedical Engineering Society (1student)	$600
Pacific Sociological Assoc. Conference (10 students)	$3,900
Total	**$55,500**

*The Institute for STEM & Diversity contributed $500 additional research dollars for Spring 2018

Demographics of Fall 2017 and Spring 2018 Undergraduate Research Fellows

Discipline	Research Awards Received
Anthropology	1
Biology	2
Civil Engineering	2
Computer Science	1
Electrical Engineering	1
Geophysics	1
Geosciences	3
Mechanical Engineering	1
Mechanical Engineering	2
Microbiology & Biochemistry	1
Molecular Biology	1
Physics	1

Gender	Research Awards Received
Female	7
Male	10

Race/Ethnicity	Research Awards Received
Hispanic/Latino	7
Caucasian	12
Other	5
Note: Students could be included into more than one category according to both their race and their ethnicity.	

Pacific Sociological Association Conference Attendees—HERC Travel Award

Student Name	Discipline	Award Received
Erin Applegate	Sociology	Travel
Jeff Cates	Sociology	Travel
Joshua Cox	Sociology	Travel
Ashlee Jenee Enbysk	Sociology	Travel
Michelle Fretwell	Sociology	Travel
Christina Kopper	Sociology	Travel
Lampe Lampe	Sociology	Travel
Harbor Neher	Sociology	Travel
Erin Neumeier	Sociology	Travel
Jacqueline Phillips	Sociology	Travel

Fall 2017 HERC Research Fellow Student Abstracts:

Omar Betancourt
Faculty Mentor: Dr. Jim Browning, Department of Mechanical & Biomedical Engineering
Research Title: Development of a Phase-Controlled Magnetron Experimental Fixtures

Magnetrons are microwave vacuum electron devices that use the interaction of electrons with a slow wave circuit in a crossed electric and magnetic field. For most magnetrons, phase is almost never preserved, which makes it difficult to synchronize an array of magnetrons to achieve higher total power output. This research is focused on developing a cavity magnetron by utilizing gated field emission arrays. The electron injection is controlled by the gate field emitter arrays (GFEA) in order to control the phase of the device. An experimental system is being designed and fabricated to demonstrate the phase control concept using a commercially available cooker magnetron as the test device. It has the potential to improve radar systems, medical imaging, particle accelerators, etc.

Donato Callahan
Faculty Mentor: Dr. Sondra Miller, Department of Civil Engineering
Research Title: Air Quality and Particulate Matter

Particulate matter (PM) can be a combination of solids and liquids including dust, soot, smoke and sand. Fine particles--defined as having a diameter less than 2.5 microns, PM2.5--pose varying negative health and ecologic effects. These in turn can have economic effects. Adverse health effects of PM2.5--which are easily inhaled and get trapped deep in human lungs--can cause an irregular heartbeat, decrease lung function, trigger asthma symptoms, cause non-fatal cardiac arrest, and lead to death for those with pre-existing respiratory issues. Ecologic effects include changes in freshwater pH, nutrient imbalances, and loss of ecosystem diversity. This research focused on understanding the effects of air quality--specifically PM--on human health, ecologic, and economic effects.

Vanessa Campfield
Faculty Mentor: Dr. Owen McDougal, Department of Chemistry

Research Title: Isolation, Purification and Characterization of Novel Steroidal Alkaloids from *Veratrum californicum*

Cyclopamine and other steroidal alkaloids found in *Veratrum californicum* are known teratogens which inhibit the Sonic hedgehog (Shh) signaling pathway which has resulted in embryo deformities including but not limited to cyclopia; as observed in lambs. This pathway is also active in over 20 types of cancer; allowing overproduction of cancerous cells and tumor growth. Examination and analysis of alkaloid extractions from *Veratrum californicum* has confirmed various abundancies of cyclopamine and other alkaloids in different sections of the plant; with the highest abundancy residing in the root and rhizome section. Observation of bioactivity through the use of Shh Light II cells shows the greatest pathway inhibition is found from the root and rhizome portion of the plant compared to the leaf and stem portions. Further analysis of the root and rhizome extract by High Pressure Liquid Chromatography and MS has verified the presence of uncharacterized, novel compounds. This project concentrates on extracting, isolating and characterizing these novel compounds followed by testing bioactivity levels of the Shh pathway for synergistic effects caused by various combinations of novel compounds with cyclopamine.

Andrea Carrizales
Faculty Mentor: Dr. Gunes Uzer,
Research Title: Effects of Lamin A/C Depletion on Nuclear Structure and LINC Complex

It is hypothesized that silencing the lamin A/C gene, LMNA, will caused deformation in the nucleus of a mammalian cell. In order to test this, we transfected Mesenchymal Stem Cells with an siRNA transfection reagent and used fluorescence imaging to analyze the results. The results showed that silencing LMNA affects both Nesprin 1 and Sun 1 proteins, which are part of the LINC complex, and changes nuclear shape.

Karen Fulk
Faculty Mentor: Dr. John Ziker, Department of Anthropology
Research Title: Food Sharing in Siberia: Social Network Analyses Using Frequencies of Transfers Versus Nutritional Values and Quantities Shared

Informal household networks are utilized for tundra foods distribution in Ust'-Avam, Taimyr Region, Russia. Most families in Ust'-Avam rely upon subsistence for their livelihood, chiefly hunting, fishing and trapping. Variation in household ability and household interest in subsistence activities create inequalities in local food production. To adapt to subsistence challenges, food exchanges occur between kin and neighbors, thereby redistributing foods and decreasing food inequalities between households. These exchanges are vital to buffer consumption risk, especially in particularly vulnerable households. A focal sample of ten women in the community provides the core of a food sharing network of 51 households. The food transfers are portions of meat and fish transferred to the women from primary procurers or their intermediaries, as well as the women's sharing of these foods to additional households. Using the results of social network analysis, we consider the frequencies of these transfers, and the quantity and nutritional content (total calories, protein and fat content values) and calculated monetary valuations of exchanged items. In considering who gives what to whom, this research provides yet another opportunity to examine

relevant variables and their effects within the widely debated explanatory hypotheses of food sharing.

Joel Johnson
Faculty Mentor: Dr. Jodi Brandt, Department of Human Environment Systems
Research title: Statistical Analysis of Idaho Counties Through USDA Census and Survey Data

The management of public lands has widespread implications for the regions they influence. For National Forests, management plans are developed to cover 30 year periods, and the current plan for the Salmon-Challis National Forest (SCNF) is being updated in accordance with the 2012 Planning Rule. The revisions are being made with a focus on ecological, social and economic sustainability. In this study, we examine three counties within SCNF area-of-influence, and compare them with four similar counties outside the SCNF region. We track how farm sizes change over time through differences in total cattle, average herd size, and the total number of farms. We used data compiled by the USDA Census and Survey programs at 5 years intervals from 1978 through 2012 and analyzed trends using repeat-measured ANOVA. Results showed that the number of cattle and average herd size declined over time ($p < 0.001$) but we found no significant difference in the number of farms over time ($p = 0.37$). These results will inform analyses of the effect of changing National Forest management, i.e., allowable grazing, on the ranching sector in the Salmon-Challis area and provide information for decisions on the management level.

Cybil Lesbyn
Faculty Mentor: Dr. Daniel Fologea, Department of Physics
Research Title: Models of intercellular communication through passive propagation of electrical signals

Continuous communication between cells is essential for creating and maintaining fundamental functionalities of cellular assemblies. Such fast communication pathways are controlled by chemical and physical signals that employ intra and extra cellular components of only closest neighbors. However, electrical signals may quickly propagate for long distances through extra cellular environments owing to their particular electrical properties. To explore such possibilities, we modeled the cellular environment by considering a connected network of passive circuit elements composed of capacitive and resistive elements. The electrical model was tested in simulations to investigate the passive propagation of electrical signals in response to point stimulations consisting in local membrane depolarization of single cells. Our results suggest that physiologically-relevant electrical signals may propagate long distances in a short time, which may provide passive pathways for inter-cellular communication. In accordance to the electrical model, these communication pathways are equally effective for both excitable and non-excitable cells. Consequently, passive communication may substantially contribute to electrical-based communication in brain and muscles. In addition, the model may be expanded to investigate signaling between non-excitable cells such as bacteria, which could be further exploited to better understand the role played by long-distance electrical signaling in bacterial colonization and biofilm formation.

Erika Petzinger

Faculty Mentor: Dr. Marcelo Serpe, Department of Biological Sciences
Research Title: Identification of a Dark Septate Fungus That Forms a Symbiotic Association with Artemesia Tridendata

In previous work, we isolated a dark septate fungus from *Artemisia tridentata* (big sagebrush) roots. In this study, we used partial sequences from three genes to identify this fungus. Based on phylogenetic analyses, the isolated fungus appears to be a non-described species within the *Darksidea* genus or a closely related sister group. The *Darksidea* is within the family Lentitheciaceae in the Pleosporales and the Ascomycota. To investigate the nature of the symbiotic association, we analyzed the root tissues colonized by the fungus and the effect of inoculation on seedling growth under *in vitro* conditions and in soil. The hyphae of the fungus penetrated the epidermis, cortex, and vascular cylinder and were detected in between and inside root cells. After two month of growth *in vitro*, non-inoculated and inoculated seedlings had similar root lengths and fresh weight. However, dry weight was higher in non-inoculated than inoculated seedlings ($p < 0.05$). In soil, inoculation did not affect the fresh weight of seedlings. Based on the results *in vitro* and in soil, the effect of the isolated fungus on sagebrush seedlings was somewhat affected by the growing environment and ranged from slightly parasitic to commensalistic.

Wesley Sandidge
Faculty Mentor: Dr. Michael Callahan, Department of Chemistry
Research Title: Analyzing Variability in Exoplanetary Eclipses

A transit occurs when a planet passes in front of its star as seen from Earth, which causes the amount of light we observe from the star to drop while the planet is crossing the face of the star. A secondary eclipse occurs when the planet passes behind the star, during which time the star blocks out light from the planet. Studying observations from NASA's Kepler Mission of exoplanetary transits and eclipses allows us to study the variability of an eclipse from one transit to another. Variability in an eclipse could result from variations of atmospheric condensates or volcanic activity on the planet. The Kepler Science Team has provided a Python package called lightkurve. This package allows data from the Kepler, K2, and TESS missions to be easily analyzed and plotted. The lightkurve package can be used to plot the data for the exoplanets that we are targeting in our study. In this presentation, we discuss our work looking for variability in the eclipses of two short period planets: HAT-P-7b, a hot Jupiter orbiting an F8 star.

Spring 2018 HERC Fellow Student Abstracts:

Jessica Carlson
Faculty Mentor: Dr. Clare Fitzpatrick, Department of Mechanical & Biomedical Engineering
Research Title: Manipulating Cartilage Geometry on a Three-Dimensional Model of the Knee Joint

Computer modeling is increasingly prevalent in the medical field. In the Computational Biosciences Lab (CBL), we generate 3D models from magnetic resonance (MR) images to address clinical issues on a subject-specific basis. Within the knee joint, cartilage tissue lines the surfaces of bones and must be reproduced accurately in our simulations to appropriately capture load transfer and cartilage

stresses. Using computer modeling programs, we can create a 3D model and transform it into a mesh. The cartilage mesh compromised of a series of nodes and elements. By identifying the nodes on the edges of the cartilage, the geometry of these nodes can then be manipulated to curve down towards the bone. The resulting cartilage mesh typically has a sharp angular edge, which can cause significant mesh distortion. When the cartilage is loaded near these regions, the distorted edge causes artificial peaks in stress. Our goal was to replace the manual process with an automated way to create a more natural curve to the cartilage as it transitions into the bone. This will be used in ongoing research in the CBL to observe the impact of injuries on the knee and evaluate the efficiency of surgical methods to these injuries.

Eli Bring Horvath
Faculty Mentor: Dr. Cheryl Jorcyk, Department of Biological Sciences
Research Title: Ovarian Cancer and the Effects of Inflammatory Cytokines

Cyclopamine is a steroidal alkaloid in *Veratrum californicum* that is a teratogen. Steroidal alkaloids from this plant have been shown to inhibit the Sonic hedgehog (Shh) signaling pathway, resulting in embryo deformities including cyclopia in lambs. The Shh signaling pathway is prevalent in over 20 types of cancer, and contributes to the overproduction of cancerous cells and tumor growth. Qualitative and quantitative analysis of *Veratrum californicum* alkaloids has confirmed various abundancies of cyclopamine and other alkaloids in different sections of the plant (leaf, stem, root/rhizome), with the highest amount of alkaloid present in the root and rhizome. Shh Light II cells provide a luminescence assay to assess the degree of Shh pathway inhibition by chemical agents. This assay was used to evaluate alkaloid ratios by plant part. The results showed the greatest pathway inhibition was achieved by the ratio of steroidal alkaloids consistent with that derived from the root and rhizome portion of the plant, followed by stem, and finally leaf. Further analysis of the root and rhizome extract by high pressure liquid chromatography and mass spectrometry has verified the presence of uncharacterized, novel alkaloids that may be potent Shh signaling pathway antagonists. The focus of the current work is to extract, isolate and characterize novel alkaloids and evaluate their bioactivity using the Shh Light II cell assay.

Denver Lloyd
Faculty Mentor: Dr. Kris Campbell, Electrical and Computer Engineering
Research Title: Speech Characterization Using a Single Memristor

The ability of a memristor device to uniquely fingerprint a spoken word was investigated. Methods of applying an audio voice signal to the memristor were explored. The most promising method found to date is described in this work. It was shown that even words that sound very similar have characteristics in their audio signal that change the memristor response.

Omid Mohammad Mousa
Faculty Mentor: Dr. Juliette Tinker, Department of Biological Sciences
Research Title: Exploring The Ideal Excipients for a Chimeric Vaccine Against Bovine Mastitis

Staphylococcus aureus is a leading cause of mastitis, or infections in the udder, in dairy cows. Mastitis causes significant financial losses for the dairy industry, and with the rapid increase of antibiotic

resistant bacteria, such as Methicillin-resistant *Staphylococcus aureus* (MRSA), it is vital to create alternative ways to fight these pathogens. Our lab is developing and testing a mucosal chimeric vaccine against bovine mastitis containing two surface antigens from *S. aureus*. The genes for the adhesins IsdA and ClfA were cloned with those for Vibrio *cholerae* cholera toxin A2/B (CTA2/B) to create the intranasally administered vaccine. The purification of this vaccine was scaled up using 1L culture volumes and D-galactose agarose affinity purification. Purified proteins were analyzed by SDS-PAGE and bicinchoninic (BCA) assay. Currently we have produced over 15 mg of vaccine for use in future bovine vaccine challenge studies. In addition, lyophilization is a well-recognized method in the pharmaceutical industry used to store biologically active drugs that are not stable in solution, or to prolong the shelf-lives of drugs. Excipients can have a great influence on performance and stability of lyophilized drugs therefore, selecting the right stabilizers is very important. IsdA chimera was lyophilized using a variety of excipients and stored at different temperatures. The stability was analyzed using native gel electrophoresis and BCA assay.

Silvia Perritte
Faculty Mentor: Dr. Nancy Glenn, Department of Geosciences
Research Title: The use of Survey 123 to improve field data collection for IDARNG

In-situ data are the cornerstone of ecological scientific research. Ecological data collected in the field are used to analyze, identify, and validate research. Given the importance of the data, special care must be taken to ensure complete and accurate measurements. The necessary attention to detail makes field data collection very time consuming. In addition, field data can consist of separate components including paper forms, GPS, and images. Survey 123, a field data collection software developed by ESRI, offers a unique way to collect complete and detailed field data with spatial information in a data survey template. Survey 123, for ArcGIS, is a simple form-centric field data collection designed to use for spatial data, survey questions, and statistics. For this study I consolidated 14 surveys for the Idaho Army National Guard (IDARNG) Environmental Division into one master survey. My work will improve the organization and efficiency of field data collection techniques for IDARNG.

Sadie Ranck
Faculty Mentor: Dr. Julie Heath, Department of Biological Sciences
Research Title: Heritability of Telomere Length in American Kestrels

The development of advanced nanoelectronic devices based on emergent 2D nanomaterials has the potential to impact energy consumption in cloud computing, reduce harm to human and planetary health, and facilitate economic development through new device design and nanomanufacturing techniques. The unique physical properties of 2D materials make them attractive for energy-related applications such as low-power nanoelectronics, efficient thermoelectrics, novel energy storage devices, and catalysts for CO_2 conversion. In particular, 2D transition metal dichalcogenides (TMDs) have direct band gaps, high carrier mobility, and can be synthesized on, or transferred to, a variety of substrates, making them ideal 2D material candidates for flexible optoelectronics. The research presented here focuses on the development of an electrical thermometry platform to characterize thermal transport in 2D TMDs and their heterostructures. This research will develop a

greater understanding of the nucleation, growth, and heat carrying properties of these materials, which are currently on the ITRS roadmap as a potential replacement for Silicon.

Luke Telfer
Faculty Mentor: Dr. Jen Pierce, Department of Geosciences
Research Title: Structure from Motion as a Viable Tool for Quantifying Diffuse Post-Fire Erosion

Idaho's 2016 Pioneer Fire burned approximately 188,000 acres in the Boise National Forest. Post-wildfire landscapes experience increased erosion with peak erosion rates occurring in the first year following the fire (Robichaud et al., 2016). Quantifying the volume of sediment removed during this vulnerable time period is challenging and has largely consisted of determining minimum sediment volumes from debris flow deposition. Few studies have included diffuse erosion from the hillslopes due to the difficult nature of obtaining such measurements.

As part of a larger investigation of total post-Pioneer Fire erosion in a catchment of Clear Creek, we seek to develop a method for determining the volume of material removed from the hillslope by diffuse mechanisms. Using mm-scale digital surface models (DSMs) constructed with handheld Structure from Motion (SfM) photogrammetry, we model pre-erosion surfaces for 12 randomly selected 1 m2 hillslope plots. The volume of eroded sediment for each plot is derived from the difference between the pre-erosion model and the post-erosion DSM. Our results suggest that low-cost SfM photogrammetry is an appropriate tool for quantitative analysis of diffuse hillslope erosion following wildfire. However, additional research is required to fully develop the methodology for pre-erosion surface modeling.

Patrick Zrelak
Faculty Mentor: Dr. Brittany Brand, Department of Geosciences
Research Title: Fabric Analysis of Unconsolidated Pyroclastic Density Current Deposits

Pyroclastic density currents (PDCs) are gravity-driven mixtures of hot volcanic tephra and gas. These events are difficult to analyze in real time. Therefore, we must use their deposits to help better understand their flow dynamics. Previous work proves that clast orientation and deposit fabric can provide information about flow processes. We use 19 samples taken from unconsolidated PDC deposits generated in the 1980 Mount St. Helens eruption to constrain PDC flow direction and dynamics. Prior to fabric analysis, these samples were lithified using a sodium silicate vacuum impregnation technique. Then, the samples were cut in three planes: horizontal (map view), parallel to flow, and perpendicular to flow. These faces were analyzed using software that automatically measures particle orientation and produces statistics that can help demonstrate fabric strength. Horizontal plane analyses have produced orientations that correlate well with previous estimations of Mount St. Helens PDC flow directions. This study demonstrates that these techniques can be used to helped constrain flow direction in outcrops without contextual information. We are hopeful that continued analyses will produced information on particle transport mechanisms and further insights into flow rheology.

Idaho State Board of Education
HERC Committee
650 W. State Street
P.O. Box 83720
Boise, Idaho 83720-0037

August 31, 2018

RE: Strategic Initiative, FY 2018 report

Idaho State University would like to thank the State of Idaho Board of Education for the award of Strategic Initiatives for $55,000.

The funds were instrumental in continuing our Undergraduate STEM Research and Mentoring program. Students were awarded funds in two categories: for research projects, and to attend a professional conference to present their research project.

Research Projects:

We were able to fund 24 undergraduate student projects with this money. The application process for the undergraduate research awards involved faculty and student. The proposal provided an outline of the STEM research, the budget, and the purpose of the project and how the faculty would mentor the undergraduate research students. One of the deciding factors in awarding funds is the mentoring plan provided by the faculty. Being mentored by a scientist is as important as doing the science. We wanted to ensure that students had a well-rounded experience. The projects total divided into semester where some students had both a summer and fall project. The students reported on how the funds were of benefit to them academically, personally, continuing on to an advanced degree, and for future career choice. These project reports are included in this report.

Travel awards to attend a Conference:

We gave out a total of 12 travel grants. Students used this money to travel to professional conferences, as a strongly suggested requirement of receiving the funds was presenting at a conference. Attending a professional conference gives students an opportunity to learn how to present research and to network with professionals in their field.

As part of the application process for travel funds, we created an essay for the students that asked three questions. The purpose of this was to give us some information about mentoring directly from the students and not what the Office for Research or the Professor believe mentoring is or should be. The first question was “Do you have a research mentor?” The second question was “What makes a good research mentor?” The last and third question asked “What type of research mentoring is the most beneficial to you, and why?” The last two questions had a minimum word count of 100 words but the majority of answers were more than two hundred and most were over 300 words. This leads us to believe that students know what mentoring is and want us to know what helps them. That is a very positive indication that students value the undergraduate program and research mentors. We will use these comments as we develop our program in undergraduate research.

Budget:

The amount of funding was $55,000.00. All funds were fully utilized with $55,000 in expenses being covered by the State Board of Education funds and approximately $920 in additional expenses that were covered by the Office for Research. Grants of $3,000 were provided that paid student wages and materials and supplies for research projects. Travel costs were included if that was needed for the research (for example, going into the field).

ISU Office for Research also covered travel costs for several students who were not eligible for these funds because of the discipline in which they are studying. There is a definite need for research funds to help all our undergraduates.

Deb Easterly, eastdebb@isu.edu

Julie Bachman, bachjuli@isu.edu

STRATEGIC INITIATIVE
Undergraduate Research Funding for STEM Majors at the University of Idaho

FINAL PROJECT REPORT

Submitted to:

Higher Education Research Council
Idaho State Board of Education
P.O. Box 83720
Boise, Idaho 83720-0037

Submitted by:

University of Idaho
Office of Undergraduate Research

875 Perimeter Drive
Moscow, ID 83844

August 31, 2018

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Executive Summary

Undergraduate research is recognized as a high-impact educational practice that increases the rates of student retention and engagement. At the University of Idaho, it is practiced throughout all units on campus and it is centrally placed in the institution's strategic plan. The Office of Undergraduate Research is taking the lead in enabling research opportunities for undergraduates at UI. It manages various competitive student grant programs that directly support student research.

During AY 2017-18, generous funding from the State Board of Education permitted UI to continue its Summer Undergraduate Research Fellowship (SURF) Program. This intensive multi-week summer research experience actively engages undergraduates in faculty- mentored, independent research. Over the course of 10 weeks, students are mentored toward increased independence on their projects. Each student is provided with a $4,000 stipend in the form of a fellowship which allows them to devote full time effort to their projects. Each student is also provided with $1,000 to help offset materials and supplies and other project-related expenses. Selection of student participants is a competitive process in which students submit research proposals to the Office of Undergraduate Research. State Board of Education funding supported 10 SURF awards during the summer of 2018.

Funding provided by the State Board of Education also allowed the Office of Undergraduate Research to support a number of undergraduate researchers during the academic year. This was accomplished through competitive Undergraduate Research Grants awarded to students during the spring semester of 2018. These grants supported semester-long research projects under the guidance of faculty mentors. These grants were in the amount of $1,000 each for materials and supplies and other project-related expenses. State Board of Education funding supported 5 Undergraduate Research Grants during the spring semester of 2018.

Almost all of UI students supported by State Board of Education funds attended and presented the results of their projects at the Idaho Conference on Undergraduate Research held in Boise in July of 2018. A few students were unable to attend the ICUR conference. In lieu of this, these students will instead be required to present their results at the UI Undergraduate Research Symposium in April 2019.

End of project feedback from students and their mentors was overwhelmingly positive. Significantly, none of the undergraduate research projects described here would have been possible without the support provided by the State Board of Education. We sincerely thank the Higher Education Research Council and the Idaho State Board of Education for making these experiences possible for our students.

Final Project Report: Office of Undergraduate Research (OUR) Undergraduate Research Grant – Spring 2018

Fellowship Recipient: Mason Anderson, Chemical Engineering, University of Idaho

Faculty Mentor: Dr. Mark Roll, Associate Professor, Dept. of Chemical & Materials Engineering

Project Title: Mechanistic Analysis of Borohydride Thermolysis

Abstract: Boron cluster chemistry has seen large strides in progress during the 20th century, but little has been investigated since for these robust hybrid compounds outside of a select number of research groups. Borohydride clusters are essential stepping stones in the path toward many phenomenal applications to areas such as nano-building blocks, super-ionic electrochemistry, and refractory precursors. However, the classical syntheses of these borohydride clusters are obscured by highly reactive and toxic neutral borane compounds and shrouded mechanisms. This project aims to analyze the mechanistic nature of these classical syntheses to employ less toxic precursory materials and afford "greener" side products.

Project Accomplishments:

1. Analyze theoretical oxidation-reduction mechanism of polarizable reactants: The initiation of cluster formation via reduction by borohydride has been proposed while some other work has shown the possibility of a radical based mechanism, determining which is correct (or both) was attempted here

Result: When the classical synthesis was modified slightly and run reacting iodine with $NaBH_4$ in diglyme, interesting results appeared. With the use of a stainless-steel needle for addition instead of a constant addition funnel (for more precise addition rates) the tip of the needle was destroyed and the broken down by the reaction slurry. This indicates a very reactive intermediate product possibly hydrogen iodide (HI), supporting our prediction.

2. Conduct continuous ^{11}B NMR to monitor transitional states: The use of time-dependent NMR allowed for minute by minute analysis of classical syntheses to help decode the inner workings of the reactions

Result: The time-dependent NMR confirmed the need for a $B_2H_7^-$ intermediate product, but the $B_3H_8^-$ was not observed in reactions at room temperature indicating the possibility of an activation energy barrier to the formation of $B_3H_8^-$.

3. Observe different borohydride product yields after varying reaction reactants: Alkyl halides and metal halides were also tested during this project for their viability as reactants with $NaBH_4$.

Result: The use of metal halides formed the target anionic cluster, but the solid metal was left after reduction by $NaBH_4$ leading to a difficult workup and extraction of the anionic clusters. The use of alkyl halides proved difficult in their higher concentration as neat liquids and their inherent ability to photoionized when exposed to sunlight, but with the dilution using the appropriate solvent and careful lighting measures lead to similar cluster formation under similar conditions.

4. Test different reaction solvents: Modifying the classical reaction solvent(s) allows for better analysis of the role played by the solvent in the reaction system

Result: The most interesting change to the system occurred using THP (tetrahydropyran), a cyclic ether only one carbon longer than a classical solvent THF (tetrahydrofuran). When THP was used the reaction only formed higher neutral borane clusters and little to no anionic borohydride clusters were observed, this could be because the neutral species borane and diborane remained in solution after formation and the borohydride (BH_4^-) was not in solution due to the low solubility of $NaBH_4$ in THP. This result could have potential benefits for in-situ generation of neutral borane clusters to avoid direct handling of the toxic neutral clusters

Summary of Budget Expenditures

Material	Price
Lithium Borohydride, 25g, 90%	$285.50
PTFE Needle, 2.11mm OD, 12" L (2)	$26.96 each
PTFE Needle, 1.57mm OD, 12" L (2)	$23.58 each
BROMINE LIQUID ACS 99.5% 100G	$46.08
Lithium Borohydride Solution in THF, 100mL, 2.0M	$107.50
5 mm Medium Wall Precision NMR Sample Tube 9" L, 400MHz (5)	$17.06 each
Adamantyl Amine, 25g, 97%	$153.00
Potassium Borohydride, 25g, 97%	$40.08
Iodomethane, 50mL, 95%	$57.25
Poster Printing	$75
Subtotal Supplies	$996.37
TOTAL	$996.37

Acknowledgment: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this Undergraduate Research Grant from the Office of Undergraduate Research. The experience this opportunity provided me was tremendous. I sincerely thank the SBOE and UI's Office of Undergraduate Research.

Final Project Report: Office of Undergraduate Research (OUR) Undergraduate Research Grant – Spring 2018

Recipient: Neale Ellyson

Faculty Mentor: Dr. David Drown, Department of Chemical and Materials Engineering

Project Title: Determining Electrical Conductivity of Battery Plate Materials

Abstract

The electrical conductivity of battery plate materials with GUITAR coated ceramic fiber additives and the cycled plates themselves was measured. University of Idaho patent-pending research on GUITAR has been shown to improve lead-acid battery performance. The measured data of varying coating process and materials were able to be compared against each other.
Additionally, the plates from finished cells were measured to provide further results.

Introduction

As a result of years of battery research done by the University of Idaho's Dr. Cheng and Edwards, further exploration of the nature GUITAR coated additives has been required. In response to that, a 4-point conductivity apparatus designed by Roper[###] yielded data on the electrical conductivity of a material providing an additional metric to weigh in considering a battery cell's performance. Using this apparatus, a methodology for determining the conductive property of battery plate materials can be formed for future research.

This 4-point conductivity apparatus, seen in Figure 1, consists of two copper rods, PVC pipe mounted on a base plate. The bottom copper rod is able to be removed from the base for easier clean up, then the PVC pipe is placed on top of the bottom rod, making a seal of the space inside with the O-rings on the bottom copper rod. The top copper rod is able to fit inside that PVC tube. The brass screws protruding from the top and bottom of the apparatus allow for a variety of clips to be applied for the measuring portion of the procedure.

The project was performed alongside the Lead Acid Battery Research And Testing, or LABRAT, senior design project, whose objective was to test the performance of batteries with 15, 20, 25% by volume additive in both the positive and active materials as well as a control, designated 0% by volume additive.

Method

In establishing a set procedure to measure battery plate materials, the battery plate paste was the main objective to measure. Battery plate paste consists of lead oxide, deionized water, sulfuric acid at 1.4 specific gravity, and in the case of the majority of the research a carbon-coated additive. In the scope of this project, the only additive used was GUITAR coated ceramic fibers produced in the tube furnace. The original intent was to have molds for the paste to be cured and dried in, similar to the fabrication of a battery plate on a lead grid. This required the resulting chip to be completely smooth and flat so the copper rods could make complete contact with the material. Initial trials proved that the curing process adhered the paste to the mold too much to retrieve an intact chip. The next course of action was to crush these chips into a fine powder and

measure the powder. The various preparations done for the variety of materials measured is detailed in Appendix A.1. The measurement procedure is as follows:

1) Portion out a consistent mass of the material being measured, approximately 2-3 grams is satisfactory.
2) Insert into the PVC tube placed on top of the bottom copper rod.
3) Place top copper rod inside and compress material with a weight, approximately 32 lbs.
4) Calculate the volume of the material using the known cross-sectional area of the PVC and using the reference pin to measure the length with a digital caliper.
5) Either:
   a. Using an Arbin Battery Tester, apply a uniform current for approximately ten seconds and record measured voltage
   b. Using a digital multimeter, record resistance.
6) Calculate sample conductivity per unit length

This procedure was adapted for the use of other battery plate materials, as well. For example, when measuring the GUITAR coated ceramic fibers, Step 3 required a heavier weight, yielding a more accurate measurement, due to the fibers needing more compression. Step 4 requires the knowledge of the inner diameter of the PVC tube to yield a cross-sectional area of $3.46 \cdot 10^{-4}\ m^2$. Additionally, Step 6 requires elaboration. In order to calculate conductivity, σ (S/m), resistance, R (Ω), must first be calculated using Equation 1:

$$R = \frac{\Delta V}{I} \qquad \textbf{Equation 1}$$

Where ΔV is the difference in voltage, mV, and I is the current in mA. Using this calculation, conductivity can be found using Equation 2:

$$\sigma = \frac{L \cdot R \cdot A}{1000} \qquad \textbf{Equation 2}$$

Where L is the measured length, m, from the reference pin, yielding the volume of the substance inside the PVC.

Results

In conjunction with the LABRAT design team, the conductivities of the ceramic fibers were continuously measured prior to the pasting process. These results can be seen in Figure 2.

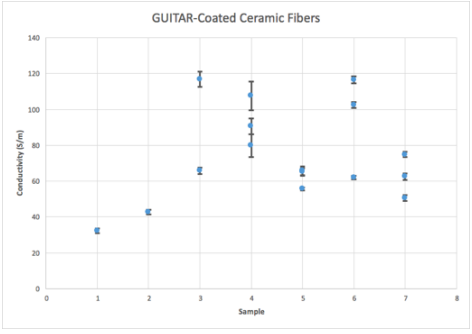
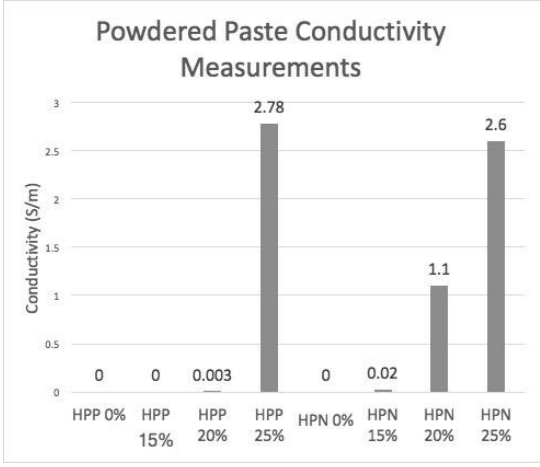


***Figure 2**: Conductivity measurements of GUITAR coated ceramic fiber*

It is noticeable that there are multiple measurements for a given sample. As the amount of volume required per battery plate pasting batch increased throughout the semester, multiple batches were produced for a single pasting session. In adapting the procedure to these variations, the batches would first be measured individually and then combined and measured once more. Once combined the fibers would be integrated at varying volume percentages to the battery paste where samples 1-4 were used in 15, 20, 25 and 25% again in the positive material battery paste and samples 5-7 were used in the 15, 20, 25% negative active material battery paste. These results were used alongside the battery cell's performance to compare which cells performed best at a given conductivity.

Finally, the conductivities of the powdered paste samples were also measured, seen in Figure 3.

***Figure 3**: Conductivity measurements of powdered battery paste materials*



Here, data reflects the understanding that adding more conductive materials to a nonconductive material yields an increase in overall conductivity. To be clear, the notation HPP stands for hand-pasted positive, and HPN, for hand-pasted negative. The 0, 15, 20, and 25 percentages represent the amount of volume added of a specific additive, in this case the GUITAR coated ceramic fibers.
Additionally, preliminary data was recorded from battery plates that had been formed and completed their cycling routine. This data can be seen in Figure 4.

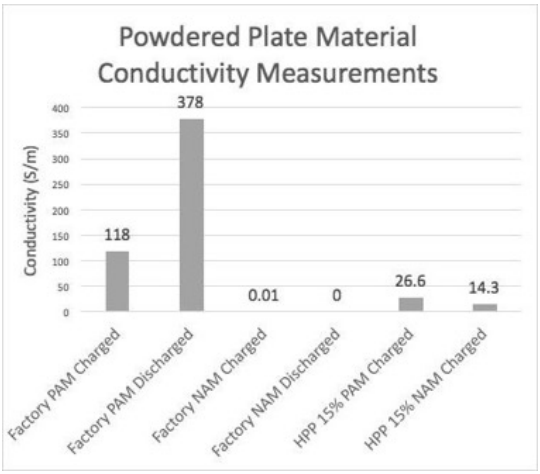


***Figure 4**: Conductivity measurements of powdered, formed battery plate materials*

To clarify notation, 'Factory PAM Charged' refers to the positive active material (PAM) plate, fabricated by the Concorde Battery Corporation, retrieved from a charged battery cell. Therefore, the 'Factory NAM Discharged' similarly refers to the negative active material (NAM) plate, also fabricated by the Concorde Battery Corporation, retrieved from a discharged battery cell. Additionally, the HPP 15% PAM/NAM Charged refer to the material retrieved from a charged positive limiting battery cell. In this case the positive active material is the only sample that contains the additive and the negative active material has no additive inside it though it was noted that it certainly seemed affected by the presence of the additive. Further details of the results are presented in Appendix A.2.

These data are only preliminary as a procedure to retrieve these plates requires additional modifications. Recovering these materials proved difficult due to the degradation of the battery plate at the end of its cycling routine. Many plates had bits of the lead grid being removed with the lead or lead dioxide 'biscuits'. Having those remnants of grid in the material seemed to drastically effect the conductivity results, as seen in the two positive active material samples.

The promising piece of data from these trials were the measurements of the 15% by volume additive in the charged state illustrates that the battery plates are still conductive after the duration of a cycling routine. Continuing these trials could corroborate or refute that the additive continues to contribute to the plate's overall conductivity.

Conclusion

Measuring the conductivities of battery plate materials has proven to be further aid in exploring the properties of a given carbon-coated additive, as well as some insight into the performance of a battery with these additives. Additionally, the battery paste materials showed measurable conductivity increase with the volume percentage increase within a paste.
Preliminary results showed that the battery plates maintain a measure of conductivity after begin formed and processed through a cycling routine.

Recommendations

To continue this research, it is advisable to explore designing a metallic lead conductivity mold to apply the paste with additive to. This scaled-down version of a battery plate then has the potential to be formed and sent through cycling routines. Furthermore, replicate measurements for fully charged and discharged battery plates should be performed and compared to the preliminary data, additionally providing a consistent and effective method of retrieval for these materials.

Appendix

A.1: Detailed preparation procedure for battery plate materials

Battery plate 'chips':

1. Starting with a standard battery plate paste composed of lead oxide, deionized water, sulfuric acid, and ligand expander in the negative paste, take approximately 10g worth of paste and apply to the PVC pipe molds of varying thicknesses using a plastic putty knife.
2. Pack the paste into the mold and flip over, ensuring to flatten both sides as much as

possible.

3. Once packed and flattened, continue the battery plate fabrication process and cure the paste inside an industrial pressure cooker, using wooden popsicle sticks as dividers between the pasted materials to ensure access for the water to properly cure them.
4. After curing for 24 hours, move the materials to an oven to be dried for as long as necessary. Due to the varying thicknesses of the chips some may require longer time in the oven. When first placed in the oven, the materials look clearly saturated with water as the paste still seems wet, but as it dries the saturation is lost and the materials begin to look lighter. When this is seen throughout the plate, it is ready to be removed from the oven, typically three to four days.
5. Once fully dried the chips are ready to be crushed using a mortar and pestle, making sure to create a fine consistency. At this point the conductivity of the battery plate paste is ready to be measured.

Used battery plate materials:

1. Starting with a cell that's completed its cycling routine, remove the desired battery plates and rinse thoroughly with deionized water to remove any sulfuric acid from it.
2. Once rinsed, transfer the used plates to an oven to dry. Similarly to drying paste, identify a fully dried plate by its entire lightness in color from loss of saturation.
3. Once dried, carefully remove the 'biscuits' of the plate, specifically the portion of lead or lead dioxide that fill the holes of the lead grid. It is important to not mix any remnants of the lead grid in with the sample as that can greatly skew the results of the conductivity measurement.
4. Once the biscuits have been retrieved, they may be placed in a mortar and pestle to be pulverized to a fine consistency and then proceed to measurement.

GUITAR-coated ceramic fibers:

1. Starting with a batch of carbon-coated fibers produced from the tube furnace, typically the fibers arrive in a clumped fashion. This requires the separation of the fibers, achieving approximately portioned sizes of a gram.
2. Once the sample is fully de-clumped it is important to thoroughly mix the sample. Coated fibers produced in the tube furnace yields varying conductivities depending on where the fibers were placed in the tube furnace, therefore mixing yields a more accurate measurement.
3. Once entirely mixed the conductivity of the sample is ready to be measured.

A.2: Detailed results of GUITAR-coated ceramic fibers

Date	Sample	Additive %Vol	Material	Conductivity (S/m)	± (95% Confidence)	Average Resistance (Ω)
1/19/18	1	15%	GUITAR Coated Ceramic Fibers from 1/17 Pasting (+ 15%)	32.28752	1.43528	1.09719
1/24/18	2	20%	GUITAR Coated Ceramic Fibers from 1/24 Pasting (+ 20%)	42.72056	1.18364	0.78396
1/28/18	3	25%	GUITAR Coated Ceramic Fibers from 1/27 Batch 1	116.73870	4.29406	0.28063
1/28/18	3	25%	GUITAR Coated Ceramic Fibers from 1/27 Batch 2	65.74906	1.82229	0.63746
1/31/18	4	25%	GUITAR coated ceramic fibers from 1/27 Batch 1 (Redo)	107.62359	8.00954	0.40553
1/31/18	4	25%	GUITAR coated ceramic fibers from 1/27 Batch 2 (Redo)	90.56589	4.45080	0.26524
1/31/18	4	25%	GUITAR coated ceramic fibers mix of Batch 1&2	79.86605	6.35907	0.87664
2/5/18	5	15%	GUITAR coated ceramic fibers from 2/3 Batch 1	55.65801	0.70664	1.35078
2/5/18	5	15%	GUITAR coated ceramic fibers from 2/3 Batch 2	65.87138	2.42920	0.83906
2/5/18	5	15%	GUITAR coated ceramic fibers from 2/3 Mix of 1&2	65.22990	2.12672	1.06700
2/13/18	6	20%	GUITAR Coated Ceramic Fibers from 2/11 Batch 1	61.88446	0.931066	0.758131
2/13/18	6	20%	GUITAR Coated Ceramic Fibers from 2/11 Batch 2	116.5937	1.948212	0.486503
2/13/18	6	20%	GUITAR Coated Ceramic Fibers Present Mix	102.4777	1.753561	0.447022
2/21/18	7	25%	GUITAR Coated Ceramic Fibers from 2/17 Batch 1	74.76046	1.498315	0.697715
2/21/18	7	25%	GUITAR Coated Ceramic Fibers from 2/17 Batch 2	50.55383	1.534483	0.952798
2/21/18	7	25%	GUITAR Coated Ceramic Fibers Present Mix	62.54501	1.879595	0.773358

A.3: Scanning Electron Microscope Results

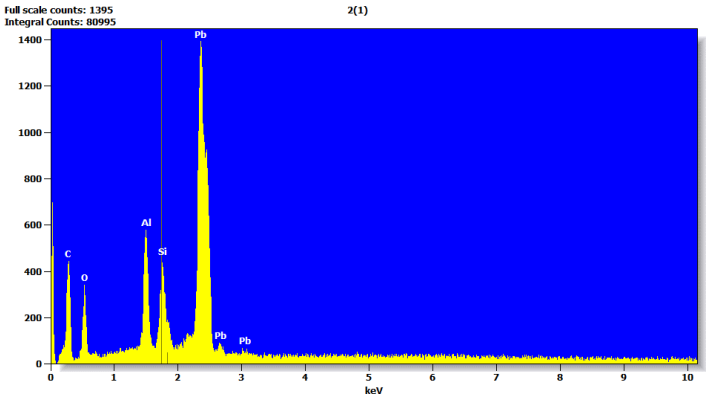


Figure 5. This graph is a general EDS survey of the region of the 20% fiber loading positive plate shown in Fig. 6. This shows the presence of primarily Pb, as would be expected, Al and Si from the fibers, O from the positive active material as well as the fibers.

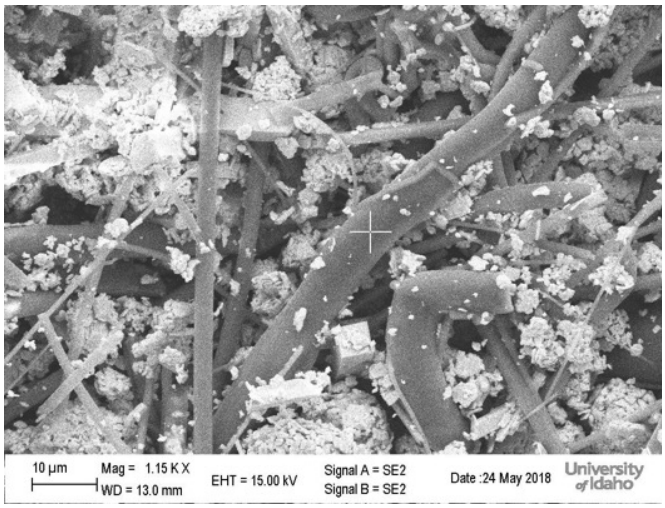


Figure 6. 1.15K X view of the 20% fiber loaded positive plate. The crosshair marks the spot sampled using EDS shown in Fig. 7.

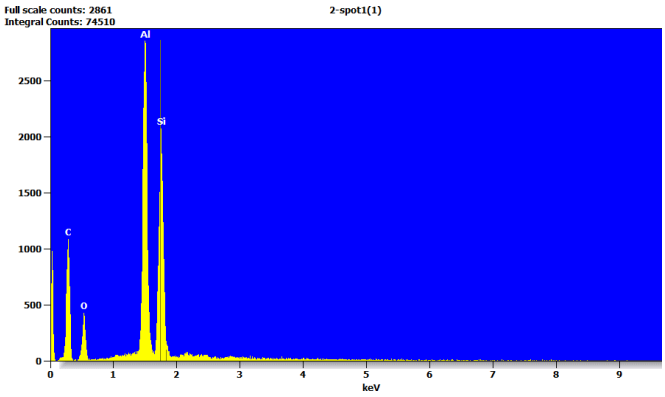


Figure 7. EDS analysis of the spot marked in Fig. 6. This indicates the strong presence of Al, Si, and O in the fiber as would be expected. It also shows a strong presence of C which indicates that the GUITAR coating is intact on the fiber.

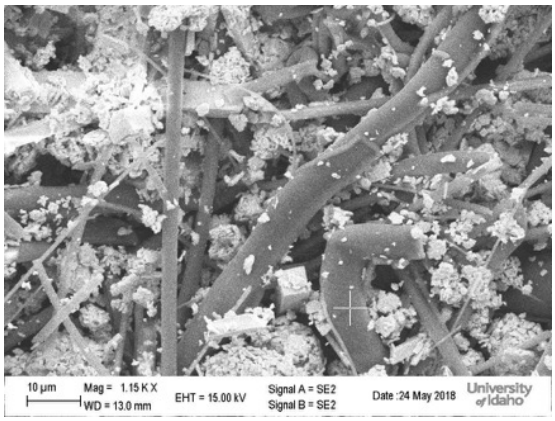


Figure 8. The same view of the plate shown in Fig. 6 except the spot sampled for EDS is moved to a different fiber. Analysis shown in Fig. 9.

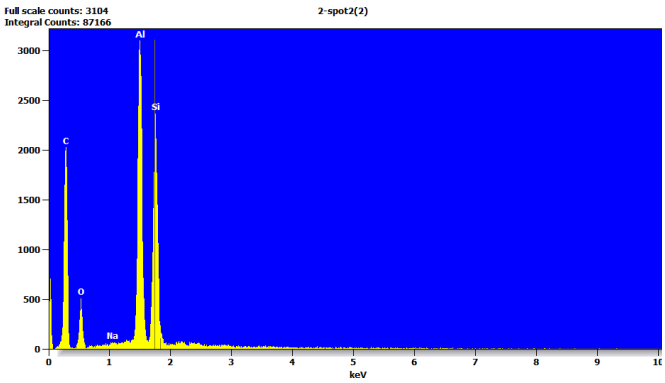


Figure 9. EDS analysis of the spot marked in Fig. 8. This indicates the strong presence of Al, Si, and O in the fiber as would be expected. It also shows a strong presence of C which indicates that the GUITAR coating is intact on the fiber. The indicated presence of sodium is likely indicates that the fibers contain some level of NaO.

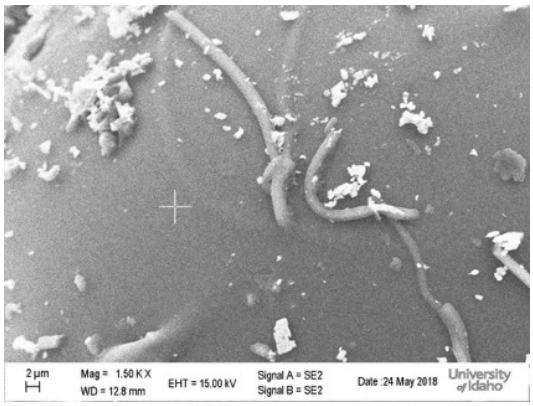


Figure 10. Location of EDS spot scan on a portion of a fiber in the 25% loading positive active plate

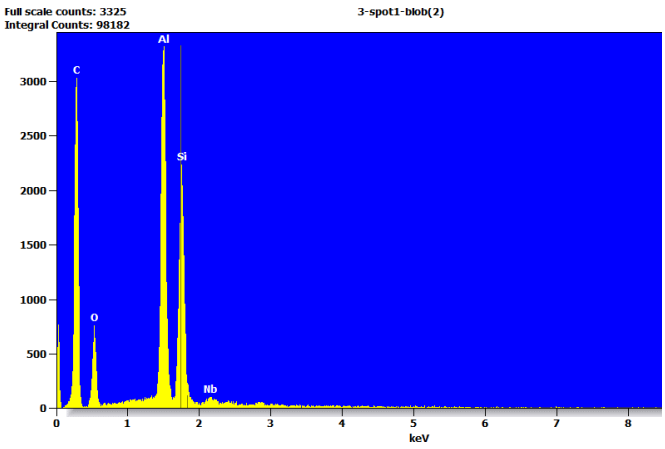


Figure 11. EDS analysis of the spot marked in Fig. 10. As in Fig. 9, the presence of GUITAR on the fiber is strongly indicated. It is unclear as to the source of the Nb peak as there are no elements with x-ray emission energy levels easily confusable with Nb.

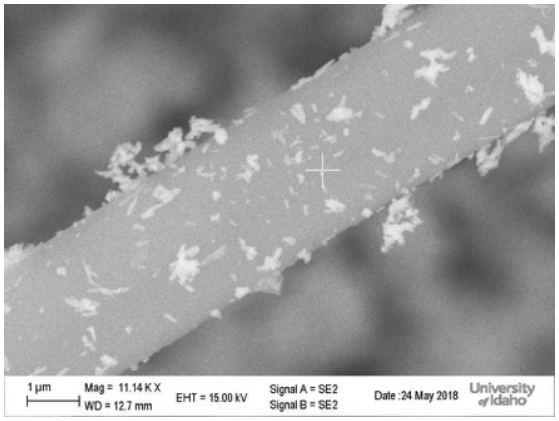


Figure 12. Location of EDS analysis of a fiber found in a sample taken from a 15% fiber loaded positive plate identified as 'charged'. Analysis results shown in Fig. 13

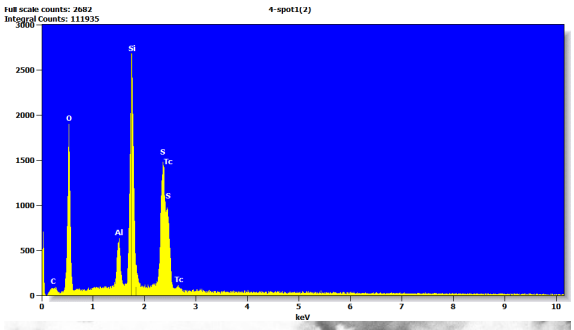


Figure 13. EDS analysis associated with Fig. 12. Only a small amount of C is detected on the sample. This indicates that little if any GUITAR remains on the fiber. S and Tc peak results from an energy level confusion with Pb and indicates a strong presence of Pb on the sample. This is observable on Fig. 12 in the form of the white flakes.

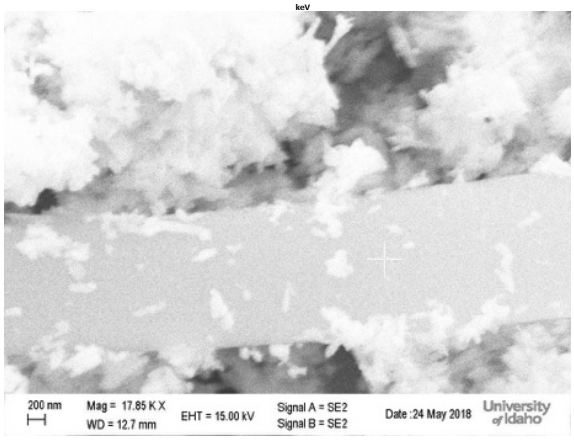


Figure 14. Location of EDS analysis of a fiber found in a sample taken from a 15% fiber loaded positive plate identified as 'charged'. Analysis results shown in Fig. 15

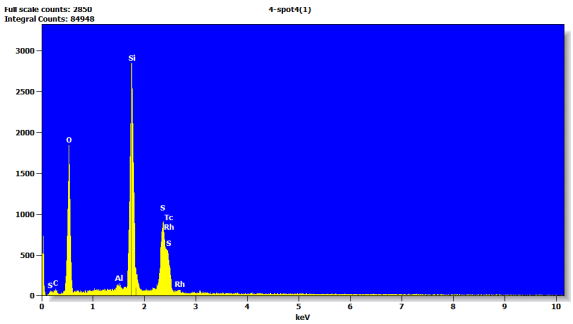


Figure 15. EDS analysis associated with Fig. 14. Only a small amount of C is detected on the sample. This indicates that little if any GUITAR remains on the fiber.
S, Rh, and Tc peak results from an energy level confusion with Pb and indicates a strong presence of Pb on the sample

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Final Project Report: Office of Undergraduate Research (OUR) – Spring 2018

Grant Recipient: Jacquelin Martinez-Alvarez, Chemical & Materials Engineering, University of Idaho

Faculty Mentor: Dr. Matthew Bernards, Assistant Professor, Department of Chemical & Materials Engineering

Project Title: Air-brushed nonfouling drug delivery patches

Abstract: A significant challenge in the field of biomaterials is the nonspecific adsorption of proteins to implants. Upon implantation, this nonspecific protein adsorption triggers the natural foreign body response leading to encapsulation and failure of the device. Zwitterionic materials are excellent at resisting protein adsorption. For this reason, we are investigating the zwitterionic polymer poly(sulfobetaine methacrylate) (polySBMA). Using polySBMA, our goal is to produce nonfouling-polymer-microfibers by airbrush-spraying. Airbrush-spraying is a novel and innovative technique. To date we have explored the influence of spraying pressure, nozzle diameter, distance to collector, polymer molecular weight, and solvent. We have also optimized the use of a photo-polymerization reaction to reduce the water solubility of the resulting microfibers. The long term goal is to use these microfibers to create a high-surface-area drug delivery platform.

Project Accomplishments

1. Perfected polymerization technique
   Description: Free-radical polymerization was used to produce polySBMA. The reaction took place under nitrogen protection. In the reaction, varying concentrations of potassium chloride (KCl) were used to vary the molecular weight of the polymer.
   Results: "Mega-batches" of polySBMA, at different molecular weights, were successfully produced. Varying the molecular weight proved to be important in microfiber production. As the concentration of KCl increased, molecular weight decreased, which also decreased fiber diameter. We found KCl to be optimal at a concentration of 2.5 M.

2. Optimal spraying solvent
   Description: The polySBMA was viscous enough to need a solvent for spraying. The following solvents were tested: acetone, ethanol, and aqueous sodium chloride (NaCl(aq)). When testing NaCl(aq), the concentration of NaCl was varied to have an insight as to how fiber diameter changes. KCl concentration was kept constant at 2.5 M.
   Results: PolySBMA was unable to dissolve in acetone nor ethanol, however, it did dissolve in NaCl(aq). As the concentration of NaCl increased, fiber diameter decreased. We found NaCl to be optimal at a concentration of 0.30 M.
   *****Note: It is optimal to have smaller fiber diameter, to allow for high-surface-area.

3. Varied spraying conditions
   Description: To produce uniform microfibers, a variety of spraying conditions were tested: spraying pressure, spraying nozzle diameter, and distance to collector. KCl and

solvent NaCl concentration were kept constant at 2.5 M and 0.30 M, respectively.
Results: Uniform microfibers were produced when pressure was at 30 psi, nozzle diameter was at "2-rotation wide", and the distance from collector to air-brush sprayer was at 10 cm away.

4. Examined the use of a UV-photo-polymerization reaction to reduce water solubility
Description: After a successful production of uniform microfibers, water solubility was tested by soaking the resulting microfibers in water. They instantly dissolved upon exposure to water, thus came the idea of introducing a UV-photo-polymerization reaction to help reduce water solubility of the resulting microfibers.
Results: Water solubility reduced significantly with the use of a UV-photo-polymerization reaction. After exposure to water, the microfibers kept their structure and uniformity.

5. Optimal photo-initiator concentration
Description: Although water solubility was reduced, at the initial tested photo-initiator concentration (introduced in the photo-polymerization reaction), the resulting microfibers had some noticeably large chunks of undissolved photo-initiator within them. For this reason, photo-initiator concentration was examined.
Results: By reducing the photo-initiator concentration from 0.089 M to 0.009 M, mixing was optimized and the photo-initiator chunks were no longer present.

Summary of Budget Expenditures

Supplies	Cost
Air-brush sprayer (3x)	$45.06
Photo-initiator (1x)	$112.09
Frame for system (1x)	$403.20
Monomers (2x)	$257.38
Petri dish 100X15mm (1x)	$110.64
Ethanol 1 gal (1x)	$23.63
Poster printing	$48
Total spent	**$1,000**

Conference Presentation: This research was presented at the 2018 UI Undergraduate Research Symposium and at the 2018 Idaho Conference on Undergraduate Research in Boise, ID.

Acknowledgment: This research could not have been as successful as it has been without the generous support of the Idaho State Board of Education. I truly appreciate the support given to me in the form of an Office of Undergraduate Research Grant.

Final Project Report: Office of Undergraduate Research (OUT) Summer Undergraduate Research Grant – Spring 2018

Grant Recipient: Cheyanne Myers, Animal Sciences, University of Idaho

Faculty Mentor: Dr. Gwinyai Chibisa, Department of Animal and Veterinary Sciences

Project Title: Determining what causes differences in feed efficiency in cattle raised on rangeland

Abstract: Currently the global population continues to grow at a fast rate, which is increasing the demand for food. However, given the finite amount of resources, such as land and water, meeting this demand is becoming harder. Therefore, improving production/feed efficiency in animal agriculture could be the solution. In Idaho, the cattle industry is a major part of the economy and most cattle are raised on rangeland. Determining whether feed efficiency for rangeland cattle could be improved will help Idaho producers produce more meat with less cattle and reduce their feed costs. Although there is information on what accounts for differences in feed efficiency in animals raised in intensive management systems (feedlots), not much is known about animals raised on rangeland. Therefore, the objective of my study was to determine whether there are differences in protein metabolism in animals that are classified as efficient and inefficient in converting feed to meat when raised on rangeland. I conducted gene expression analysis for markers of protein synthesis and degradation, and also measured amino acid concentration in blood. Having this information is critical as it will add to the body of knowledge that will enable genetic selection of cattle with high feed efficiency.

Project Accomplishments

1. My first goal was to determine the differences in protein metabolism in efficient vs. inefficient cattle that are raised on irrigated pasture compared to rangeland.

   We know that cattle raised on rangeland have to work harder (traveling to graze and drink water), and deal with a number of stressors, environmental conditions. All of these factors can affect the rates of protein synthesis and breakdown. We know that proteins build up a majority of the body. Proteins function as enzymes, nutrient transporters, and to help the body grow and repair.

   Result: We used q-PCR to determine transcript abundance of markers of protein synthesis and degradation in skeletal muscle samples. Unfortunately, during our runs we noted that we had low RNA abundance. Therefore, we have no numbers to report for gene expression. However, we are currently troubleshooting and trying to determine if we can salvage the situation. I sent 6 samples to the on-campus Genomics Resources Core lab to determine the profile and concentration of RNA in our samples. I am also planning to run RNA integrity gels to determine if our samples can be used for q-PCR. We ordered the supplies that are needed and are waiting for them to be delivered. We will report back to you once we have all that information, and I am continuing to work on the project.

2. My second goal was to determine the plasma amino acid concentration in animals that are efficient vs. inefficient

Determining plasma 3-methylhistidine, urea-N and amino acid concentration can be useful in studying protein metabolism. Amino acids are the building blocks for protein. However, body protein can be broken down to provide amino acids in times of need, which can cause muscle wasting. Muscle wasting can cause an increase in the concentration of 3-methylhistidine in blood. Amino acids in excess of requirements cannot be stored and are further broken down to a carbon skeleton and ammonia. Ammonia ends up converted to urea-N, which is then excreted in urine.

Result: There were no differences (P = 0.214) in the plasma concentration of 3-methyhisitidine, an indirect indicator of muscle protein breakdown. We observed no differences (P = 0.750) in the blood urea-N (BUN) concentration. Blood urea-N concentration can be used as a measure of amino acid breakdown. Based on the 3-methylhistidine and BUN data, it is possible that there were no differences in body protein breakdown between efficient and inefficient cattle. Plasma Cit concentration was higher (P = 0.025) whereas plasma Try concentration tended (P = 0.088) to be higher in inefficient than efficient cattle. We also noted that the concentrations of Ser ended (P = 0.088) to be higher in efficient compared to inefficient cattle. However, the plasma concentrations of Asp, Thr, Asp, Glu, Gln, Pro, Gly, Ala, Val, Met, Cys, Iso, Leu, Tyr, Phe, Lys, Arg, His and Orn did not differ ($P \geq 0.139$) across treatments.

Summary of Budget Expenditures

Supplies	**Cost**
TF 5X-TAQMAN FAST UNIVERSAL ($1,000 from this award, remaining $42.85 provided by mentor)	1,042.85
TOTAL	$1,042.85

Conference presentations: The poster submitted with this project was presented at both the UI university-wide Undergraduate Research Symposium in Moscow, ID, as well as at the ASAS convention in Vancouver, BC, Canada, in July 2018.

Acknowledgement: I would like to acknowledge the University of Idaho and the Idaho State Board of Education for providing funding in the form of an Undergraduate Research Grant. This project has been a huge and very positive learning experience for me. Without the funding provided to me through this program, I would not have been to conduct this research. Thank you!

Final Project Report: Office of Undergraduate Research (OUR) Undergraduate Research Grant – Spring 2018

Grant Recipient: Frankie Scholz, Biological Sciences, University of Idaho
Faculty Mentor: Dr. Tanya Miura, Department of Biological Sciences

Abstract: Respiratory syncytial virus (RSV) is an intracellular pathogen that infects people of all ages. RSV is responsible many deaths each year and currently, there is no licensed vaccine. In an alternate form of therapy, monoclonal antibodies can be used to treat infection by neutralizing the virus. We want to investigate the ability of RSV to mutate under stress of a human monoclonal antibody, D25. We hypothesized that RSV will mutate under stress of a sub-inhibitory dose of D25 resulting in escape from neutralization. Molecular modeling done by our collaborators will also accurately predict these mutations. To test this, we introduced RSV to rounds of selection in the presence of D25 and allowed time for mutations to arise. After ten rounds of selection in HEp-2 cells, viral mutants required significantly more antibody for neutralization. The mutants were sequenced for specific amino acid changes and compared to the modeled predictions done by our collaborators. These results will help us better understand how RSV evolves to escape neutralization.

Project Description: The antibody response is crucial for prevention and treatment of RSV. Many antibodies are in development, including D25. The development of a vaccine based on the F protein found on RSV is currently a high priority in the field. RSV is capable of mutating and evolving to escape antibody recognition to avoid neutralization. In this study, we want to select for antibody escape mutations with antibody D25 in the F protein of RSV. Our findings will aid in the work of our collaborators in the physics department who are modeling the F protein to predict possible escape mutations the virus may develop to evade the antibody recognition.

We hypothesize that RSV will mutate under stress of a sub-inhibitory dose of antibody D25 resulting in escape from neutralization. We also predict that molecular modeling done by our collaborators will accurately predict these mutations. To test this, we exposed the virus to antibody D25 in a dilution that hinders the virus but, does not completely neutralize it. This was done in a low dose of D25 (0.16 µg/mL) for five passages. The mutant populations from the five passages were then hit with a higher dose of D25 (2.5 µg/mL) and pressured for another five passages of selection. In this way, the virus will adapt and form mutations to escape the antibody (*See Figure 1.1)*.

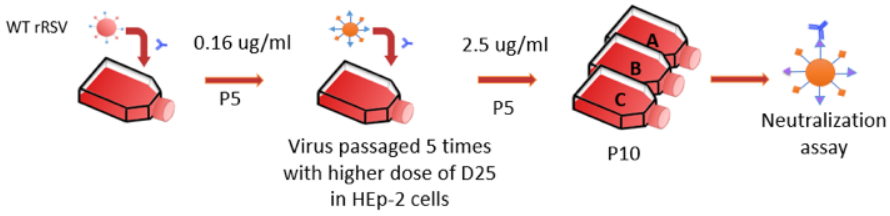


Figure 1.1 *Selection of Antibody Escape Mutants*
HEp-2 cells were incubated with wild-type virus infection. Neutralizing antibody D25 was introduced in a low dose then a higher dose to select for natural mutations in the F protein that allow virus to grow in the presence of D25.

We used genetic sequencing to identify the antibody escape mutations. Further experiments will confirm that these mutations lead to antibody escape and determine how the mutations affect the growth of RSV in the absence of antibodies. This study will not only lead to an understanding of how RSV changes to avoid antibody neutralization but, will also provide data to test the predictions made by molecular modeling.

Project Accomplishments: Thus far, data illustrates that a significantly higher dose of antibody D25 is required to completely neutralize the passaged RSV compared to that of the wild-type RSV. The wild-type RSV that was used to begin the passage experiments was completely neutralized at 1.3 µg/ml, and populations passaged 10 times in the presence of D25 now require >80 µg/ml of antibody to completely neutralize the virus *(See Figure 1.2).*

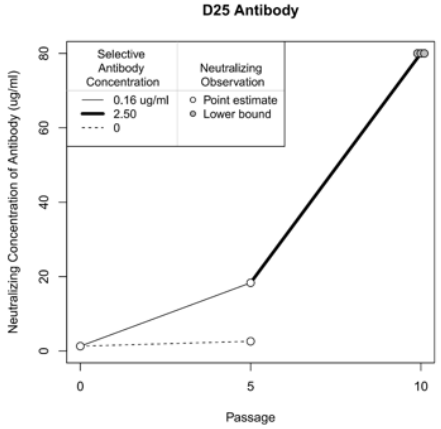


Figure 1.2 *Neutralizing Antibody Concentration of Mutants Across Passages*
Neutralizing Concentrations were obtained through neutralization assays. HEp-2 cells were incubated in a 96-well plate with 1:2-fold dilutions of D25. Cells were monitored for viral infection for 7 days.

The virus populations passaged five times in 0.16µg/ml of D25 and those passaged an additional five in 2.5µg/ml for a total of ten passages were isolated for their RNA, reverse transcribed to cDNA, and then further amplified by PCR. The PCR products were sent to Elim BioPharm for sequencing of the F gene.
Data received from the sequencing shows a single point mutation in the F protein in mutants evolved from the first five passages of selection: N208Y. In this mutation, an asparagine residue was mutated to a tyrosine and this change alone prevents the access of D25 to a small hydrophobic pocket on the F-protein by steric hindrance. A second point mutation arose in addition to the first in the mutant populations that were passaged ten times in the presence of D25: Q202R. This mutation of a glutamine to an arginine abolishes three hydrogen bond interactions with D25 originally present in the wild-type. Both mutations affect the ability of D25 to bind and interact with the F-protein. These data suggest that RSV successfully evolved to escape neutralization by D25.

Budget Expenditures:

Materials	Cost
Plasmid Preparation Kit	$250
Mutagenesis Reagents	$300
Chemicals to make buffers	$50
Plastic ware	$225
Cell culture media	$100
Poster	$75
Total	$1,000

I presented a poster of my work at the UI Undergraduate Symposium in April of 2018 and at the 2018 Idaho Conference of Undergraduate Research (ICUR) in Boise.
Acknowledgement: I would like to thank the State Board of Education for providing me the opportunity to conduct my research. I am very proud of the research I did this and I learned a tremendous amount that will have a large impact on the rest of my future endeavors. Without the support from SBoE, I would not have been able to participate in this research.

Final Report: Office of Undergraduate Research, Summer Undergraduate Research Fellowship, summer 2018

Fellowship Recipient: David Behrens, Department of Geological Sciences
Mentor: Dr. Jeff Langman, Department of Geological Sciences
Project title: Evolution of Carbonate Weathering and Nanoparticle Release

The purpose of this experiment was to evaluate detection methods of a new mechanism for carbonate weathering—ejection of nanoparticles from the mineral surface by unidentified repulsive force(s). This new mechanism of carbonate weathering has recently been detected (Levenson and Emmanuel, 2017a) and heavily debated (Le Merrer and Colombani, 2017; Levenson and Emmanuel, 2017b). Such a mechanism could explain why geochemists have struggled to quantify the dissolution rate of carbonates. For this study, it was hypothesized that the use of a dynamic light scattering (DLS) analyzer could detect solution nanoparticles ejected from the surface of the carbonate mineral that would allow for quantification of the nanoparticle distribution and stability (zeta potential). The original proposal was to use smithsonite [$ZnCO_3$], but sufficient quantities for a reasonable price could not be located; therefore, the subject mineral was changed to calcite, which was used by Levenson and Emmanuel.

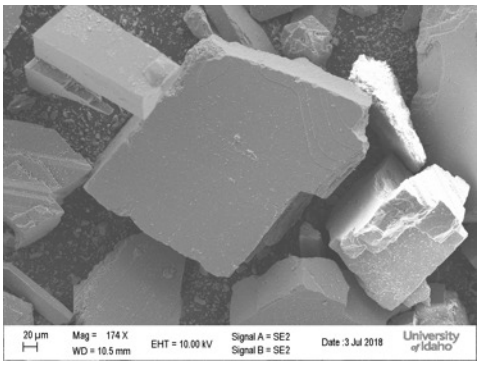


Figure 1. Scanning electron microscope image of calcite grains used in the weathering experiments.

To facilitate the weathering of the calcite and produce a solution for analysis, four weathering chambers were constructed (Fig. 2). A non-traditional design was chosen to enhance the rate of weathering and allow for a more rapid production of potential ejected nanoparticles. The chambers were comprised of 20-cm long, clear plastic tubing with a 5-cm diameter. A black rubber cap and air valve was installed on one end, while the other end contained a layered construction consisting of protective mesh, 23-µm filter, 11-µm filter, protective mesh, snap in drain, and rubber cap with drain spigot. The filter end allowed for draining of each chamber after each experiment. A small hand pump could be attached to the top valve, which allowed for air to be pumped into the tube to force water through the filters. Each weathering chamber was filled with an aqueous solution of a variable volume, typically one circumneutral and the other slightly acidic at each temperature condition. While the weathering chambers were in use, they were placed on shaker tables set to 80 rpm, which was believed to be sufficient to minimize boundary layer issue but not fast enough to inadvertently cause physical weathering processes (collision). In order to test Arrhenius behavior of the weathering processes, two of the chambers were placed in a walk-in refrigerator at 5ºC and two chambers in the lab at 21ºC.

Each of weathering chamber contained 100 g of ground calcite. The calcite was ground to a diameter range of 125 to 300 µm to maximize available surface area for weathering. It was hypothesized that any particles that passed the 11-µm filter would have been produced by the particle-ejection mechanism. The drain water was collected after each

experiment for analysis as raw water (unfiltered) and 450-nm filtered water to examine a potential large range of micro- to nano-particles (raw) and nanoparticle-only range (<450 nm). All samples were analyzed for particle size distribution and zeta potential (stability) with the DLS analyzer.

Figure 2. Images of the weathering chambers on the shaker tables and in the drain stand setup.

Initial experiments did not produce the expected range of particles or the particle concentration was below detection limits. Believing the initial results were due to low concentrations of the particles in solution, the amount of water in the tubes was reduced, the pH of the solution was adjusted, and the length of time that the tubes were agitated was increased. During the course of the experiments, the water from the weathering chambers underwent several other tests to obtain relevant environmental data. For each drain solution pH, Eh, and electrical conductivity were measured, which allowed fro the determination of the amount of buffering and dissolution to be quantified. Initial data indicated that the conductivity of the water remained relatively low until the acidity was substantially increased. A Hach spectrophotometer was used to measure water hardness, to determine the mass of calcite that was being lost during each experiment. Unfortunately, these experiments did not detect particles of the predicted size.

In order to compensate for the unsuccessful weathering chamber experiments, small scale experiments were instituted alongside the chamber experiments. The DLS can be set up to allow for water to flow through the detector, but the equipment necessary is expensive and would require a larger experiment. To replicate this “flow through” design, 100 mg of calcite was added directly to DLS cuvettes with 4 mL of water at neutral, slightly acidic and very acidic conditions. These cuvettes were placed on the shaker table with the larger weathering chambers and analyzed with the chamber samples. While these did yield particles in solution in the water, results were inconsistent between trials.

It is difficult to draw specific conclusions since the nanoparticles were never consistently detected. It is possible that the original study that examined the ejection process solely by examining changes to the mineral surface was not detecting nanoparticle ejection but area-specific (lattice point) dissolution of the carbonate mineral surface at specific locations. If the ejection weathering mechanism does occur, a few possibilities exist for why they were not detected under these experimental conditions. First, it is possible that the ejected nanoparticles are not stable and quickly dissociate into their constituent ions in solution. Additionally, it is possible that the nanoparticles are produced, but they are produced at such low concentrations as to not be detected by the DLS. This possibility also offers a potential reason that these particles have not previously been identified; they are not a major component of the weathering of calcite.

References

Le Merrer, M., Colombani, J., 2017. Comment on “Repulsion between calcite crystals and grain detachment during water-rock interaction” by Levenson and Emmanuel, 2017. Geochem. Perspect. Lett. 1–2. https://doi.org/10.7185/geochemlet.1747

Levenson, Y., Emmanuel, S., 2017a. Repulsion between calcite crystals and grain detachment during water–rock interaction. Geochem. Perspect. Lett. 133–141. https://doi.org/10.7185/geochemlet.1714

Levenson, Y., Emmanuel, S., 2017b. Reply to comment on “Repulsion between calcite crystals and grain detachment during water-rock interaction” by Le Merrer and Colombani, 2017. Geochem. Perspect. Lett. 3–4. https://doi.org/10.7185/geochemlet.1748

Budget

Material	Supplier	Unit Cost	Units	Subtotal	Total
Hach hardness kit	Hach	$74.05	2	$148.10	$165.89
Shaker table	Sonic Supply	$325.00	1	$325.00	$337.44
Calcite (Bulk pack 1 kg)	VWR	$31.00	2.5	$77.50	$84.54
Mortar and pestle	Amazon	$206.00	1	$206.00	$219.35
Filters	Cole Palmer	$20.71	1	$20.71	$30.63
Caps + drains	Amazon	$3.30	8	$26.40	$46.12
Plugs and felt	Spence’s			$15.00	$46.23
2” tubing	Grainger	$41.40	2	$82.80	$82.80
				Total:	$1,013.00

*The SURF award provided $1,000 in project-related supplies and a $4,000 student fellowship. The remaining funds ($13) were provided by Dr. Langman.

Acknowledgement: The support provided by the State Board of Education in the form of a Summer Undergraduate Research Fellowship was greatly appreciated. I would not have been able to participate in this research project or gain the experience I did. Thank you very much.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2018

Fellowship Recipient**:** Zachary Blume, Department of Biological Sciences

Faculty Mentor**:** Dr. Diana Mitchell, Department of Biological Sciences

Project Title: Modulation of the Retinal Immune Environment in a Zebrafish System of Rod Photoreceptor-Specific Degeneration

Abstract: Activated and pro-inflammatory microglia, along with accompanying local inflammation, are associated with human retinal degenerative disease. However, it remains unclear if these aspects of the immune response are symptomatic or directly initiate and/or contribute to disease pathology, such as the death of additional retinal neurons. One hypothesis for continued loss of neurons in retinal degenerative disease is that microglia may engulf, or possibly initiate cell death of, otherwise healthy neurons. Our project attempts to test this hypothesis using a zebrafish system in which rod photoreceptors die due to a toxic transgene (XOPS:mCFP), but cone photoreceptors survive. We first characterized microglial characteristics in XOPS:mCFP retinas compared to wildtype and found that microglia localize to the photoreceptor layer and engulf dying rods, but total numbers of microglia are similar. Next, we successfully induced a pro-inflammatory retinal immune environment by intraocular injection of zymosan (a pro-inflammatory compound), as indicated by infiltration and division of immune cells in the retina and gene expression of selected transcripts. Our next goal is to determine if this induction of a pro-inflammatory retinal environment may result in subsequent cone death or disappearance in XOPS:mCFP retinas, thus directly probing contributions of a dysregulated immune environment to retinal degenerative disease.

Project Accomplishments:

1. Our first goal was to show that we could induce an inflammatory immune response in the zebrafish retina. More specifically, in the retina of a zebrafish transgenic line with rod-photoreceptor specific degeneration.
    a. The retina contains two distinct types of photoreceptors responsible for vision: rods and cones. Rods are responsible for dark/light distinction and visibility in dimmer light, while cones are responsible for brighter, color vision. In humans (and mice), when rod photoreceptors degenerate due to a genetic mutation, cones inexplicably die as well. One hypothesis for this subsequent cone death is microglia activation – activation of the resident immune cells of the retina. It is thought that by responding to the programmed rod death the microglia may inadvertently consume or kill cones via proinflammatory mechanisms. However, in a zebrafish system in which rods die due to a rod-specific transgene, the cones survive. Our goal was to show that we could activate the microglia in that zebrafish system.

Results: We used the compound zymosan, which is a fungal carbohydrate molecule that mimics infection (by binding TLR 2). Zymosan triggers an immune response without the resulting pathology of a real infection. We found that we were able to induce

an inflammatory response in the retina shown by increased immune cell infiltration and up regulation of selected proinflammatory genes in zymosan injected eyes.

2. Our second goal was to determine if the induced proinflammatory state resulted in subsequent cone death.

Results: We found that cell death slightly increased in zymosan injected eyes when compared to saline injected control eyes. Interestingly, we found (using the fluorescent cyan reporter for rods) that the increase in cell death appears to be attributed to cell population other than rods in zymosan injected eyes.

3. Our third goal was to determine if the induced proinflammatory state resulted in subsequent increase in cell proliferation
    a. Zebrafish have the incredible ability to regenerate their retinal tissue in response to damage. An increase in cell proliferation following a proinflammatory induced state may indicate an attempt at regeneration in response to damage caused by immune activation.

Results: We found that cellular proliferation showed a trend of increasing in zymosan injected eyes when compared to saline injected controls eyes, although it was not statistically significant.

Future Directions: From this experiment we have proved we can induce inflammation in the zebrafish retina. The future of this project will be to determine if sustained inflammation (for longer periods) in the retinal microenvironment may result in subsequent cone death or other signs of pathology in the rod-specific degeneration line of zebrafish. This will be more akin to simulating a chronic degenerative disease that we observe in humans. Moving forward we hope to directly probe the contributions of a dysregulated immune environment to retinal degenerative diseases.

Summary of Budget Expenditures:

Integrated DNA Technologies (IDT) qPCR primers	$285.24
LifeTechnologies Superscript IV cDNA synthesis kit and Power SYBR Green qPCR mix	$714.55
Subtotal for supplies	$999.79
Stipend (before tax)	$4,000.00
Total	$4,999.79

Conference Presentation: I presented a poster of my work at the 2018 Idaho Conference on Undergraduate Research (ICUR) at Boise State University and I will be presenting my research again at the UI Undergraduate Research Symposium in April 2019 as well.

Acknowledgement: The support provided by the State Board of Education in the form of a Summer Undergraduate Research Fellowship was genuinely appreciated. The experience is one that I feel was inexplicably valuable. It opened new opportunities for a career path I had never considered before, and further invigorated my curiosity towards my field of study. Only with this support from the SBOE was I able to participate in this research, for which I am extremely grateful.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2018

Fellowship Recipient: Beau Horenberger, Mathematics, University of Idaho

Faculty Mentor: Dr. Jennifer Johnson-Leung, Department of Mathematics, University of Idaho

Project Title: Calculating Siegel Modular Forms

Abstract: The aim of this research project was to build a code base for calculating Siegel modular forms of paramodular level N. Siegel modular forms have Fourier expansions indexed by binary quadratic forms. Thus, the first step in representing Siegel modular forms is to identify and calculate good representatives for appropriate equivalence classes of these binary quadratic forms. This is the essential problem that was solved in the course of this research. This code base will have practical use for further research in Number Theory, specifically in verifying examples of the paramodular conjecture. The resultant objects also have applications to hyperelliptic curve cryptography. The project will be mentored by Jennifer Johnson-Leung, who will use this computational procedure for further research.

Project Accomplishments

1. The first goal was to show that the index of $\Gamma_0(N)$ in $SL_2(\mathbb{Z})$ was finite so that we could generate finite cosets of binary quadratic forms.

This was achieved in a series of proofs calculating the cardinalities and indexes of related sets. It was shown first that $|SL_2(\mathbb{Z}/p^e\mathbb{Z})| = p^{3e}(1-1/p^2)$, then $|SL_2(\mathbb{Z}/N\mathbb{Z})| = N^3\prod_{p|N}(1-1/p^2)$, so this is the index $[SL_2(\mathbb{Z}) : \Gamma(N)]$. Next, we found that the map $\Gamma_1(N) \to (\mathbb{Z}/N\mathbb{Z})$ given by $\left(\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right) \to b \bmod N$ surjects and has kernel $\Gamma(N)$ and that the map $\Gamma_0(N) \to (\mathbb{Z}/N\mathbb{Z})^*$ given by $\left(\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right) \to d \bmod N$ surjects and has kernel $\Gamma_1(N)$. From these, we derived that $[SL_2(\mathbb{Z}) : \Gamma_0(N)] = N\prod_{p|N}(1+1/p)$, as desired.

2. Next, we aimed to prove that the cosets of $\Gamma_0(N)$ in $SL_2(\mathbb{Z})$ had a method for determining distinguished representatives.

This was achieved by proving there is a bijection between the cosets of $\Gamma/\Gamma_0(N)$ and the projective space $\mathbb{P}^1(\mathbb{Z}/N\mathbb{Z})$. Once this was done, we proved one could generate representatives for the cosets by showing all members of the projective line $\mathbb{P}^1(\mathbb{Z}/p^n\mathbb{Z})$, with p a prime and n a natural number, of the form $(1:u)$ where $u = 0, 1, .., p^n - 1$ and $pu, 1$ where $u = 0, 1, p^{n-1} - 1$ represent different equivalence classes. Thus, we could compute representatives using this as the basis for an algorithm.

3. The next goal was to implement these proofs in a program which could calculate

representatives for binary quadratic forms.

The program was written in C++ to efficiently calculate these representative binary quadratic forms in their matrix form. Additional functions and classes were written to handle math- ematical operations involving matrices, primes, and moduli.

4. Finally, we intend to use this program to calculate the Fourier coefficients for twists of Siegel paramodular forms.

Work has begun on this end, and the program is still under development. Although more work remains to generate and twist coefficients, the analysis of the coefficients already has a code base from the previous goal, making the remaining work minimal. This work will be continued to completion in approximately the next month.

Summary of Budget Expenditures:

1. Stipend: $4000

2. Cost for UI Undergraduate Research Symposium Presentation: $75

3. Travel expenses for presenting research at AMS National Meeting in Batimore, MD:

(a) Flight to Baltimore, round trip: $450 (b) Hotel for 3 nights: $225

4. Misc. Project expenses: $250

Total expenses (sans stipend): $1,000 + $4,000 stipend

Acknowledgement:

I would like to sincerely thank the State Board of Education for the wonderful oppor- tunity I was provided through the Summer Undergraduate Research Fellowship. The support provided by the SBOE made this a truly rewarding eye-opening experience for me.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2018.

Fellowship Recipient: Hannah Jaeger, Biological Sciences, University of Idaho
Faculty Mentor: Elizabeth Fortunato, Professor, Department of Biological Sciences

Project Title: Determining the Benefit Human Cytomegalovirus Gains by Down Regulating the Basement Membrane Protein Nidogen-1

Abstract:
Human Cytomegalovirus (HCMV) is the most prevalent cause of neurological birth defects, ranging from microcephaly to sensorineural hearing loss. This study aims to elucidate the benefit HCMV derives from modifying a particular cellular process to more efficiently disperse infected cells. Within 6-8 h post infection, HCMV begins to downregulate Nidogen-1 (NID1), an important component of the extracellular matrix (ECM) secreted by endothelial cells, by both protein stability and decreased mRNA transcription. To determine if the absence of NID1 increases dispersal of HCMV, we have designed a series of transmigration assays that utilize human umbilical vein endothelial cells (HUVECs) seeded onto a polycarbonate membrane. THP-1 monocytes are seeded on top of the HUVEC monolayer and total transmigration of the monocytes is measured after 24 and 48 hours. Infection of HUVECS has been shown to increase this transmigration rate, presumably via ECM modifications. Five different treatments of HUVECs, ranging from full HCMV infection to just NID1 knockdown, were used to test our hypothesis that downregulation of NID1 increases transmigration. Preliminary results with uninfected monolayers yield an average of 24% transmigration. Ultimately, we believe the targeting of NID1 provides HCMV a selective advantage, which exacts a negative toll on the developing fetus.

Project Accomplishments:

1. Development of CRISPR knock out cells for NID and control CRISPR

A. Lentivirus transduction and initial verification.
HUVECs have been successfully transduced with a previously verified NID1 KO CRISPR and control CRISPR encoding lentiviruses, followed by selection with puromycin to ensure delivery of the lentivirus genome (encoding both Cas9 and NID1 targeting guide RNA). After a short selection in puromycin, NID1 KO and control resistant cells were seeded at an equal density and harvested 72 h post plating for supernatant and cell lysate analysis for NID1 via Western blot. Initial analysis showed strong NID1 knockdown. However, after several passages of pooled cell populations, NID1 levels returned to control levels, indicating single cell cloning was necessary to obtain populations with strong/continuous NID1 knock out before preforming the transmigration assays.
B. Single Cloning
We seeded approximately 50-100 HUVEC CRISPR NID1 Knock out and CRISPR control cells onto 10cm plates. Single clones that were large enough to be visible to the eye were circled and then evaluated to make sure no other clones were touching or too close. Colonies were carefully removed and placed into separate wells until cell counts were high enough to analyze via Western blots. We were are currently analyzing NID1 levels in these single clones. A population will be selected that have NID1 knocked out and then transmigration assays will be performed.

2. Infection of HUVECs with HCMV and Adenovirus

A. Monitoring infection of HUVECs

HUVECs were infected with HCMV at an MOI of 15 or mock infected for four hours after which time fresh media was added. HUVECs were also infected with either a backbone Adenovirus or one encoding HCMV tegument protein pp71 for 30 mins at room temperature, then fresh media was added. After 24 hours, all wells were washed and fresh media was added. We were able to successfully monitor the infection by staining coverslips and counting the percentage of infected cells using antibodies against viral proteins. Between 80-90% of cells were successfully infected.

B. Infection of transwell monolayers.

Once a confluent monolayer was formed the same method of infection was used. After 24 hpi monolayers were rinsed and transmigration assays were performed.

Results: More migration of THP1s (about 8%) was seen in infected monolayers as compared to the uninfected controls. Adenovirus infections (using a multiplicity of infection of 10) were too harsh and killed most of the monolayer. Further testing has shown that adenovirus infections at an MOI=1 are sufficient to deliver pp71 to all cells. A second round of infections is currently underway.

3. Transmigration Assays

The main goal of this project was to determine if knock down of NID1 plays an important role in disseminating HCMV. To test this we used transmigration assays of parental HUVECs, CRISPR KO cells, HCMV infected monolayers, and adenovirus carrying pp71 infected monolayers. We were able to test several different monolayers of the parental HUVECs as well as just the transwell insert to determine a baseline for the other cells.

Results: Migration of THP1s was approximately 27% per 24 hours in just the transwell compared to transwells that had a confluent monolayer of HUVECs which was about 12% per 24 hours. The CRISPR cells were initially tested, however, results matched the parental cells due to the high amounts of NID1 within the population of cells. Migration of THP1s through HCMV-infected HUVEC monolayers was higher than the mock, but further testing will need to be done to repeat these results. The adenovirus infection was initially tested, but the infection will need to be adjusted to see the affects that pp71 has on migration.

Budget (not including research stipend- $4000)

DESCRIPTION	UNIT COST	TOTAL COST	DESCRIPTION	UNIT COST	TOTAL COST
Human Endothelial Cell Growth Medium	105.47	316.41	INSERT,24W PLT,PET,8UM CS48	137.01	137.01
Shipping	64.25	64.25	VWR PASTEUR PIPET 9IN CS1000	49.12	49.12
Nidogen-1/Entactin Mouse anti-Human, Clone: 302117, R&D Systems™	279	279	FLASK TC PLG CP 550ML CS50	80.38	$80.38
Fisherbrand™ Easy Reader™ Conical Polypropylene Centrifuge Tubes	56.96	56.96	S&H	3.98	3.98
Oligoes x 2 ea	6.08	6.08	Liquid Nitrogen	2.61	2.61
S&H	4.2	4.2	**Total**		1000

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2018

Fellowship Recipient: Jared Lambert, Biological Sciences, University of Idaho

Faculty Mentor: Diana Mitchell, Professor, Biological Sciences, University of Idaho

Project Title: Live Imaging to Probe the Role of Microglia in Developmental Apoptosis in the Zebrafish Retina

Abstract: During mammalian retinal development, programmed cell death (apoptosis) occurs in large waves in a spatio-temporal fashion to generate functional retinas. In zebrafish comparably smaller waves have been observed and are thought to represent fine-tuning of developing retinal tissue (Biehlmaier 2001). It is appreciated that tissue resident macrophages clear apoptotic cells, however, specific roles for microglia in cell survival/death and clearance during retinal development in zebrafish have not been documented (Petrie 2015). We used an inducible system to specifically deplete macrophages/microglia during retinal development and found an increased number of apoptotic cells in the retina compared to controls. This finding suggests that microglia clear larger numbers of apoptotic cells than is currently appreciated, or alternatively, that microglia provide survival signals to developing retinal cells. To address clearance of apoptotic cells during zebrafish retinal development in real-time, we live imaged fluorescently labeled retinal microglia together with apoptotic cells using acridine orange (AO). We observed that microglia sense and engulf cells prior to AO incorporation, and that engulfed apoptotic cells undergo dynamic movements as microglia continue active migration. This suggests that apoptotic cells visualized in fixed tissues using AO may not represent true levels of apoptosis and their retinal locations may differ from where apoptosis was initiated.

Project Outcomes

1. Our first goal was to determine the optimal live imaging conditions to visualize the retina of embryonic zebrafish.

We needed to visualize developing retinas for a period of 8 hours. To do this, we used a transgenic zebrafish that expresses a fluorescent marker on macrophages, and acridine orange to visualize the apoptotic cells in the retina. Zebrafish are sensitive to environmental conditions, and so we used a climate control box on a Nikon Spinning Disk Confocal microscope to maintain environmental conditions during the imaging process, and limited the exposure to lasers in order to keep the fish alive while trying.

2. Our Second goal was to determine the role of microglia in developmental apoptosis within the zebrafish retina.

Microglia are the macrophages of the Central Nervous System (CNS), and are known for their immune functions. Preliminary data showed an increase in developmental apoptotic cells in retina that had been depleted of microglia. Using live imaging, we sought to determine if they were actively involved in clearing out apoptotic cells, or if they were sending survival signals to keep cells from apoptosis.

Result: Microglia were visualized actively engulfing apoptotic cells.

3. Quantifying the rate of clearance of apoptotic cells by microglia, and duration of acridine orange signal.

After visualizing the retinas, we determined the rate of clearance of apoptotic cells by microglia over the 8 hour period. We found that microglia clear out apoptotic cells at a rate of about 1.2 hours During this quantification, we also noticed that microglia would phagocytize apoptotic cells before the acridine orange marker would appear, which means that they were sensing the cells before they reached DNA fragmentation. The signal would last anywhere from 10-80 min. This means that the microglia probably sense the apoptotic cells long before the marker appears, and that the time for them to digest the apoptotic cells differs.

4. Quantifying displacement and speed of apoptotic cells.

We noticed that apoptotic cells would be moved about by the microglia once they were phagocytized. We quantified the displacement and the speed of apoptotic cells, and found that the displacement varied between cells, but that the speed of the cells was consistent. The average speed for was around 1.5μm/min, which is similar to other experiments done on microglia outside the retina.

Jackson Immuno fluorescently conjugated secondary antibody $307.63
Biovision CaspGLOW caspase staining kit $223.50
Fisher Scientific superfrost slides $468.85

Budget

Supplies	Cost
Jackson Immuno Fluorescently Conjugated 2° Antibody	$307.63
Biovision CaspGLOW caspase staining kit	$223.50
Fisher Scientific superfrost slides	$468.85
Subtotal Supplies	$999.98
Stipend (Before Tax)	$4000.00
Total	$4999.98

Conference Presentation: The poster was presented at the 2018 Idaho Conference of Undergraduate Research (ICUR) in Boise, Idaho. It will also be presented at the 2019 University of Idaho Undergraduate Research Symposium.

Acknowledgements: I appreciate this research opportunity that was made possible by the Idaho State Board of Education, and plan to continue the research that was started this summer during the course of the next year. Without these funds I would not have been able to carry out the research.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2018

Fellowship Recipient: Garrett E. Larson, Biological Sciences, University of Idaho

Faculty Mentor: Kristopher V. Waynant, Assistant Professor, Chemistry Dept

Project Title: Ionic and Biomolecular Movement through Functionalized Thin Filmed Polymers

Abstract: Ions and biomolecules are essential for many functions of the human body such as bone strength and development, muscle contractions, and cell functions like membrane transport and membrane potentials. This experiment will use post-polymerization functionalization to bind to Calcium ions (Ca^{2+}), using ion selective electrode polymers; this binding could be a way of monitoring calcium levels in the body. The polymer scaffolding will be made from Poly-(3-sulfopropyl methacrylate). This sulfonic acid polymer will capture Ca^{2+} through negatively charged terminal ends, in acidic environments, that can ionically bond to the Ca^{2+}. These polymers will be grown on carbon nanotubes. We will characterize these polymers with transmission electron microscopy (TEM) and RAMAN spectroscopy. The transport of Ca^{2+} through the polymer surfaces will be monitored by measuring the voltage change on the polymer electrode as a Calcium solution is passed over it. A device was designed to hold the polymer in a closed system to allow the solution to pass over it and out, which allows us to monitor the concentration of the calcium solution after polymer interaction.

Project Accomplishments

1. The main goal of this project was to grow 3-sulfopropyl methacrylate (SPMA) onto carbon nanotubes.

   The carbon nanotubes first needed a surface on them that would be able to be polymerized onto, the surface we used was poly dopamine. The terminal hydroxyl groups on the ends of the dopamine molecules work as a good starting point for polymerization. Next we attached 2-bromoisobutyryl bromide (BiBB) to terminal hydroxyl groups of the dopamine to act as our initiator. Finally we polymerize SPMA onto the terminal hydroxyl groups of the dopamine with atomic transfer radical polymerization (ATRP).
   Results: The polymerized carbon nanotubes (CNT-PDA-SPMA) have a terminal sulfonic acid that has a negative charge that has the potential to bind to Ca^{2+} ions.

2. The next goal was to design a device that can work as an electrode to monitor Ca^{2+} binding to the polymer surface.

   The device needed to be able to show a change in voltage as more of the sulfonic acid charges are filled with Ca^{2+}. In order to do this the device needed a reference electrode made from conductive Silver ink and the other electrode is a line of conductive Silver ink with a break in the middle where we drop cast our CNT solution to complete the circuit. Connecting these two electrodes is a microfluidic channel

made from an elastomer (PDMS). We are able to push $CaCl_2$ solutions through the channel over the electrodes and monitor the voltage with various concentrations of $CaCl_2$. We used a syringe pump to obtain a constant flow rate of solution over the electrodes. We are still working on perfecting the setup of the device but it has been used to run preliminary tests with a Calcium ionophore instead of CNT-PDA-SPMA.

3. Lastly Characterization of the CNT's in their different stages of polymerization.

   Thanks to Abdulakeem Osumah we have transmission electron microscopy (TEM) images of the CNT's, CNT-PDA, and CNT-PDA-BiBB. We will soon have images of CNT-PDA-SPMA as well. We have taken infrared spectra of the CNT's at the different stages of polymerization and they are comparable to the spectra presented in the literature.

Summary of Budget Expenditures

Supplies	Cost
Syringe Pump	$290.00
Autoclave Bomb	$114.00
Lab Supplies	$252.69
Biopsy Punches	$103.79
PDMS Kit	$106.65
Tubing	$107.87
Student Fellowship	$4,000
Total	$5,000.00

Conference Presentation: I presented a poster on this project at the 2018 Idaho Conference of Undergraduate Research (ICUR) in Boise and am ready to present it at this year's UIdaho Undergraduate Research Symposium.

Acknowledgement: I appreciate the generous support provided by the State Board of Education in the form of a Summer Undergraduate Research Fellowship. This was an amazing experience for me and without the support from the SBOE, I would not have been able to participate in this research.

*The information contained below is confidential, and an invention entitled, “NueroFlux Robotics” will be disclosed shortly with the Office of Technology Transfer at University of Idaho.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF)- Summer 2018

Fellowship Recipient: Elliott Marsden, Biological Engineering, University of Idaho

Faculty Mentor: Dr. Bryn Martin, Assistant Professor, Department of Biological Engineering

Project Title: In Vitro Magnetic Nanoparticle Drug Delivery to the Central Nervous System

Abstract:
The aim of this research was to conduct preliminary experiments demonstrating the targeted delivery of fluorescently tagged magnetic nanoparticles (F-MNP) in a 3D-printed model of the cerebrospinal fluid system. CNS diseases can be difficult to treat because of the blood brain barrier (BBB). Due to the physical size of available drug molecules, the BBB prevents or severely impedes passage of necessary drug concentration to the CNS. There many central nervous system (CNS) diseases that are difficult to treat effectively with current drug delivery methods. The advantages of CSF drug delivery could be further exploited by combining chemical targeting strategies. One of these strategies utilizes magnetic nanoparticles bound to the biologic agent and a focused magnetic field to selectively target specific regions. Visualization of the spread of the F-NMPs was visualized in a poly-carbonate tube to gather data on their movement and the influence of a magnetic field on their delivery efficiency and targeting capabilities. It was discovered that a concentrated magnetic field heavily influenced the dispersion rate of the F-NMPs, and a stationary magnet was able to collect the majority of the injected particles.

Project Accomplishments and Goals

1. **Synthesize fluorescently tagged Iron(III) Oxide Magnetic Nanoparticles**

   A fluorescently tagged nanoparticle gives the ability to collect high quality imagery showing accurate particle spread and concentration throughout the spinal model. By synthesizing nanoparticles in the lab, consistent size and geometries could be replicated and held constant over all experiments.

   Result: The IONPs were successfully synthesized in the lab and employed in multiple preliminary experiments. Due to the particles small size and concentration of particles in solution, almost all UV light was absorbed, and fluorescence was only visualized with the aid of a fluorescent microscope. Transmission Electron Microscope imaging revealed that the particles that were synthesized in the lab were indeed within 10nm of the desired 50nm diameter.

2. **To develop and construct a prototype targeting system**

   A secondary model of the CNS was developed to provide increased particle visualization and the ability to completely remove all residual particles

between experimental trials. A clear polycarbonate tube with an internal acrylic rod was used as an optimized model of the human CNS. A method for transporting the particles along the spinal model was developed using a 5-axis robotic arm in conjunction with a linear stage. This provided the most precise and constant movement of the magnet along the spinal column. It was discovered that slight variations in the robotic arm pathway had a great effect on the spread of particles to the target area. Multiple movement patterns were developed to optimize spread.

3. **Optimize particle spread and deliver high concentrations of IONPs to target area**

   Using an optimal robotic arm pathway, the particles were efficiently moved, and collected in various target areas along the spinal column. The support structures for the spinal cord proved to be an interesting case of CSF mixing, and acted as an effective barrier for particle spread. Further work will need to be done on the spinal model to prevent particle clumping around any support structures.

Summary of Budget Expenditures:

Supplies*	**Cost ($)**
Robotic Arm	1,500.00
Iron(III) Oxide Nanoparticles	311.00
Magnets (N52 Disc Magnet)	29.98
LED Light STrip	51.96
Student Fellowship	4,000
TOTAL	**5,000**
***$1,000 from SURF award, remaining covered my mentor**	

Conference Presentation: I will be presenting a poster of my work at the UI Undergraduate Research symposium in the Spring of 2019. I have also participated and presented my work at the Idaho Conference on Undergraduate Research in July of 2018.

Acknowledgement: I truly appreciate the generous support provided by the State Board of Education in the form of the Summer Undergraduate Research Fellowship. This was a tremendous learning experience for me. Without the support from the SBoE, I would not have been able to participate in this summer research project.

Final Project Report: Office of Undergraduate Research (OUR) Summer undergraduate research fellowship (SURF) – Summer 2018

Recipient: Jessica Nicholson, Biology, University of Idaho

Mentor: Dr. Onesmo Balemba, Biological Sciences, University of Idaho

Project Title: Why your gut may be working against you: gut derived molecules cause dysmotility and neuropathy in high fat fed mice

Abstract:

Type 2 diabetes (T2D) is a prevalent disease in the United States, affecting 21.9 million people. Patients often suffer from gastrointestinal (GI) issues like stomach cramps and constipation. This is caused by a reduction in inhibitory motor neurons in the intestinal tract. Recent studies have shown the development of gastrointestinal dysmotility and neuropathy before the onset of T2D, and ileocecal supernatants from high fat (HF) fed mice caused dysmotility and neuropathy ex vivo. However, the specific cause of dysmotility and neuropathy are still not known. We hypothesized that fractions from HF ileocecal supernatants would cause dysmotility and neuropathy. High Performance Liquid Chromatography (HPLC) was used to separate supernatants into aqueous (water) and methanolic fractions which were tested on mice intestinal muscularis tissue. Contractions of the tissue samples were counted, and immunohistochemistry and imaging used to determine if these fractions caused neuropathy. Water fractions from HF mice caused a significant decrease in muscularis contractions after 24 hours; water fractions of standard chow fed (SC) mice and methanolic fractions of HF and SC mice did not significantly induce dysmotility. It was also found that HF water fractions caused a reduction in neuronal nitric oxide synthase (nNOS) staining, indicating that the inhibitory motor neurons were damaged. These results suggest a molecule(s) in the HF water fractions are causing dysmotility and neuropathy. Sub-fractionation and chemical analysis of these fractions will narrow down on gut derived molecules that may be causing these symptoms; and lead to treatment options before the start of T2D.

Project goals and accomplishments:

1. Test the effects of the fractions on longitudinal muscle myenteric plexus contractions at 0, 24, and 48 hours

I was able to culture my preparations in each fraction, along with a control, and record videos of the contraction of the tissue samples at all time points. I recorded the number of contractions for analysis and was able to determine that the HF water fractions were causing a significant decrease in muscular contractions, telling us that they may be causing dysmotility.

2. Determine what fractions, if any, cause neuropathy; specifically, a reduction in inhibitory motor (nNOS) neurons.

After staining the samples mentioned above and analyzing the images and data, we determined that the HF water fractions caused a significant reduction in nNOS staining, as

well as lowering the overall percentage of nNOS neurons. This shows that the HF water fraction may be causing neuropathy and a decrease in inhibitory motor neurons.

3. Identify molecules that may be causing dysmotility and neuropathy in mice fed a HF diet

This was the first step towards accomplishing this overall goal. We have successfully narrowed down on the fractions causing these symptoms, although further research must be done to identify certain culprits.

Result:
These data suggest that molecules present in the supernatant of high fat fed mice ileocecal content causes dysmotility and neuropathy in mice.

Summary of budget expenditures:

Supplies	Cost
Sigma Aldrich purchase	$263.48
Sigma Aldrich purchase	$161.07
Sigma Aldrich purchase	$84.38
Sigma Aldrich purchase	$401.10
Sigma Aldrich purchase	$41.45
Poster	$48.30
Subtotal supplies	$999.78
Stipend	$4,000
Total	**$4,999.78**

Presentation of work:
This project was presented at the Idaho Conference of Undergraduate Research at Boise State University in July 2018. Also, I will be presenting at the UI Undergraduate Research Symposium in April 2019.

Funding acknowledgement:
I truly appreciate the generous support provided by the State Board of Education in the form of a Summer Undergraduate Research fellowship. This was a tremendous experience for me. Without support from the SBOE I would not have been able to participate in this research, thank you!

Final Project Report: Office of Undergraduate Research (OUR), Summer Undergraduate Research Fellowship – Summer 20118

Fellowship Recipient: Joelle Stephens

Faculty Mentor: Dr. Ann F. Brown, Dept. Movement Sciences, University of Idaho

Project Title: Body Image, Body Composition & Energy Intake of Adolescent Aesthetic Athletes

Background: Adolescent athletes in aesthetic sports such as gymnastics and dance are often evaluated based on appearance and weight. Many of these athletes' experience heightened attention on appearance and it is common to observe unhealthy behaviors in attempt to achieve a particular physique. Purpose: The purpose of this study was to assess adolescent aesthetic athletes' body image, body composition and energy intake. Methods: Gymnasts and dancers (n=24; age 10.54±2.99) completed questionnaires regarding medical history, body image perception and food consumption. Additionally, body composition was assessed using a dual energy x-ray absorptiometer (DXA). Results: 92% (n=22) of the participants felt pretty and were happy with the way their body looked. When asked about being perfect, 79% (n=19) of the participants "didn't worry about it" while 17% (n=4) of the participants put "a lot of pressure on themselves to be perfect". Only 4% (n=1) reported feeling "bad about themselves" whereas 46% (n=11) felt "good about themselves". Body composition results showed healthy weight (37.86 ± 14.02kg), height (55.78 ±6.23in), lean mass (27.04 ±9.57kg), and bone mineral density (BMD) (0 .771 ±0.19). Total dietary intake averaged 1,984±538.7 calories, 86.70 ±11.92g/d protein,
286.60 ±53.55g/d carbohydrate and 995.65 ±414.19mg/d calcium. Conclusion: Most participants had high self-esteem and body image perception. Three gymnasts recorded at risk for low BMD and one gymnast recorded low BMD for their chronological age. Calcium was recorded below the recommended daily value (1000mg/d), while the macronutrients were above the recommended daily value (19-46g/d protein and 130g/d carbohydrates.

Project Description

Aesthetic sports are considered weight-sensitive since the artistic movements that occur during performance are most optimal when the athlete is lean and graceful (6). Aesthetic athletes become aware of the emphasis placed on achieving a lean physique at a young age often beginning as early as 3 years old (24). It has been previously established that peak performance occurs well before puberty in aesthetic sports and excess fat mass (FM) is seen as a disadvantage (33). Therefore, these athletes are subjected to heightened risk for body image dissatisfaction and eating disorders at a much earlier age than other non-aesthetic sports (9, 10, 33).

Since many aesthetic athletes are concerned about appearance, they often consume a low energy diet to maintain a lean physique (9, 34). Low energy intake can place athletes at risk for inadequate nutrient consumption resulting in inadequate recovery, fatigue, and loss of lean body mass (LBM) (34). In addition, low energy intake is often combined with heavy training loads which places aesthetic athletes at a higher risk for injury, stress, and immune system problems (34). If aesthetic athletes chronically diet, it

can impair overall health and physical function, while also causing more serious medical complications that involve the cardiovascular, endocrine, gastrointestinal, and central nervous systems (34). Additionally, delayed menarche, bone growth retardation, reduced height, weight, and FM, and increased rate of injuries can occur at an early age because of inadequate energy intake and heavy training loads in adolescent aesthetic athletes (17, 23, 31, 34).

Gymnasts have been reported to perform exercise training at higher intensities when compared to dancers which may be related to a greater chance of growth stagnation, slowed development of secondary characteristics, and delayed menstrual cycle onset (21). Although gymnasts and dancers have similar overall energy intake, as well as body image dissatisfaction and eating disorder concerns, gymnasts often have a greater overall bone mineral density (BMD) than dancers (10, 21). This may be due to gymnasts performing higher-load activity on the upper and lower body, while dancers lack the weight bearing activity in the upper body. As a result, dancers are often reported as having lower total BMD when compared to gymnasts (8, 21). Low BMD is related to factors such as energy intake and weight bearing activity, both of which increase the risk for injuries and future health problems.

Previous research has used a variety of methods to assess body image dissatisfaction, body composition, energy intake and eating disorders among aesthetic athletes (5, 7, 9, 22, 34). Understanding the relationship between body image dissatisfaction, body composition, and energy intake in adolescent aesthetic athletes can help to prevent and reduce the prevalence of eating disorders and medical complications often observed in this population. Gaps in the current literature stress the need to continue to explore possible explanations for body image dissatisfaction, eating disorders, and injury occurrence in adolescent gymnasts and dancers (1, 7, 9). Therefore, this project will investigate body image, body composition, and energy intake in an adolescent aesthetic athlete population. The project's overall objective is to evaluate the differences between early aged gymnasts and dancers' body image perception, body composition, specifically BMD and LBM, and energy intake in order to identify and develop methodology to improve overall health and performance in the future.

Accomplishments

The initial plan for the research project was to recruit fifteen gymnasts and fifteen dancers to participate to compare and contrast their body image, body composition, and energy intake. Although we are still in the process of recruiting the rest of the participants, it has been much easier to recruit the gymnasts than the dancers. As of now, 18 gymnasts have participated and only 6 dancers. The remaining 6 participants that we recruit will be dancers with the hope that we are better able to find similarities and differences in the two aesthetic athlete populations.

Though some of the participants were as young as five, all of the participants were able to complete the DXA scan with no issues. In addition, if the participant was too young to be able to read the body image/self-esteem questions, the researcher would read the questions aloud to the participant so they could choose the best option for themselves. In the end, every participant completed the DXA scan and was able to answer all of the questions to the body image/self-esteem questions, providing us with enough data to analyze and come up with results and conclusions.

Budget Expenditures

Dual-Energy X-Ray Absorptimetry (DEXA) Scans: in order to assess bone mineral density in dancers and gymnasts DEXA scans will be conducted in the HPL. Scan cost is $5.80/participant and contributes towards maintenance of the equipment. 30 participants x $5.80 =$175	$175
Participation Compensation: incentive to participate, compensation for travel to HPL and time invested in the study. 30 participants x $25 = $750	$750
Poster Printing For presentation at the Undergraduate Research Symposium	$75
Student Stipend	$4,000
Total	$5,000

Since we still have six participants coming into the lab later this month, there is $34.80 that has not yet been spent for DXA scans and $150 dollars that has not been given out to the participants for participation compensation. In addition, since this research project was not presented at the ICUR due to not having enough data recorded yet, the $75 for the poster printing will be spent by the end of this month when the poster is printed. By August 31st, all $1,000 in project funding will be spent. Results will be presented at the UI Undergraduate Research Symposium in April, 2019.

Acknowledgment: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this Undergraduate Research Grant from the Office of Undergraduate Research. I benefited greatly from this experience and I sincerely thank the SBOE and UI's Office of Undergraduate Research for making this possible.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2018

Fellowship Recipient: McKenzie Walquist, Biological Engineering, University of Idaho

Faculty Mentor: Sarah Wu, PhD. Assistant Professor, Biological Engineering

Project Title: Non-thermal Liquid Plasma Treatment for Antibiotic Removal in Aqueous Solution

Abstract: Traditional wastewater treatment processes are not able to degrade pharmaceuticals which find their way into the water system; one solution currently being explored to prevent these emerging contaminants from being released into the environment is advanced oxidation processes (AOPs), including non-thermal liquid plasma (NTLP) treatment. The NTLP process produces high energy mobile electrons and oxidizing radicals which degrade large organic molecules. In this proposed project, a novel reactor design will be used which includes a circulating treatment and discharge occurring in the liquid phase to remove three types of beta-lactam penicillins. The conclusion of this study will give results of the amount of degradation achieved, the effects of different reactor parameters on removal rates and efficiency, energy yield (mass removed per kWh), and the influence of -OH and H2O2 radicals on removal. Finally, this new reactor design can be compared to other non-thermal plasma reactors' results in order to make suggestions for its applicability in industry.

Project Accomplishments:

Objective 1: Treated solution physical properties

The H_2O_2 and COD concentrations are indicators for the chemical processes occurring during treatment. If Chemical Oxygen Demand of the samples decreased during treatment with the NTLP reactor for all three antibiotics, this would suggest that the molecules were oxidized and degraded. A hydrogen peroxide concentration increase would assist in oxidizing these compounds. A 1-hour treatment of tap water was analyzed for the hydrogen peroxide generation.

> Result: The COD levels of ampicillin and amoxicillin decreased by 18% and 17% respectively. Oxacillin decreased less than 10%. This lower change may indicate that there is a larger organic part left over after degradation. H_2O_2 concentrations consistently increased during treatment reaching around 200ppm after 1 hour, which would provide additional oxidizing potential of this treatment. pH also increased after treatment, which means there is a higher [-OH] concentration. The exact antibiotic concentrations were not able to be calculated with the proposed spectrophotometric method, but further tests will be conducted to find these removal values.

Objective 2: Effect of reactor parameters

Parameters of the reactor such as liquid flow rate, applied power, air flow rate, and starting concentrations were tested to find the most efficient operating conditions for the reactor.

> Result: In all experiments, applied power increases degradation of organic molecules. The highest energy yield, which was calculated as mass removed per kWhr, was around 300 Watts. Conversely, the lower the flow rate, the better the discharge was able to treat the solution.

Objective 3: Effect of $FeCl_2$ as a catalyst
Addition of $FeCl_2$ into a NTLP treatment has been shown to increase the production of hydroxyl, a powerful oxidizer.

Result: No consistent trend was obtained from using $FeCl_2$ as a catalyst in production of oxidizing radicals at 10 mg/L concentration.

Budget Expenditures:

Supplies	Cost
Chemical reagents and antibiotics	$89.84
Ampicillin (5g)	$35.01
Oxacillin sodium salt (2g)	$28.28
Amoxicillin trihydrate (5g)	$24.07
Passive high voltage probe	$827.80
Student Fellowship	$4,000
Total	**$5,005**

Conference Presentation: This research was presented at the poster presentation session during the Idaho Conference on Undergraduate Research (ICUR) in Boise, ID, July 25-26, 2018.

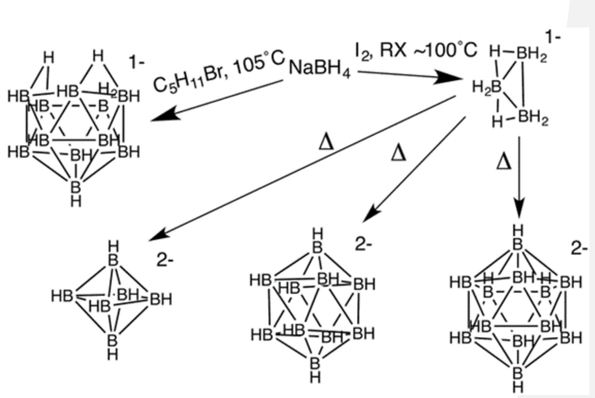
Acknowledgement: I truly appreciate the generous support provided by the State Board of Education in the form of a Summer Undergraduate Research Fellowship. This was a tremendous experience for me. Without this support from the SBOE, I would not have been

MECHANISTIC ANALYSIS OF BOROHYDRIDE THERMOLYSIS

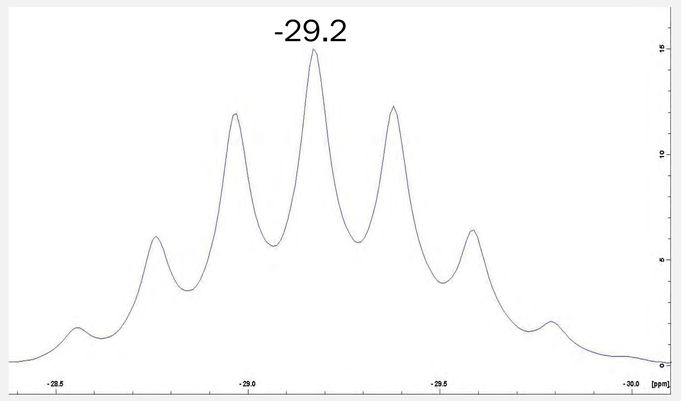
Mason Anderson, Dr. Mark Roll: University of Idaho Chemical and Materials Engineering Department

Introduction

- Borohydride clusters are synthesized with reactive/toxic neutral borane compounds such as diborane
- Oligomerization into larger clusters is dictated by heat and cluster concentration
- Little research has been done towards the synthesis of borohydride clusters utilizing shelf-stable $NaBH_4$
- Borohydride clusters show novel nano-building block characteristics, extensive electrochemical functionality of the closo-ionic borohydride clusters ($B_{12}H_{12}^{2-}$)



Cluster Synthesis Map



B^{11} NMR of $B_3H_8^-$ Product

Borohydride Clusters

- Incorporation of icosahedral borohydride clusters and closo-carboranes into refractory thin-films exhibit high temperature and radiation resistance
- Reaction solvent is critical for the dissolution of $NaBH_4$ and in-situ capture of BH_3
- The ability to selectively synthesize the $B_3H_8^-$ anion is crucial for non-toxic synthesis, but current work does not propagate beyond laboratory scale

Acknowledgments

- University of Idaho Summer Undergraduate Research Fellowship
- University of Idaho Department of Chemical and Materials Engineering

Results

Kinetics

- Reactant concentration and addition rate are critical factors
- Rapid addition can deplete local BH_4^- concentration, leading to side products
- Rate of reaction is extremely different, even for similar reactants

Solvent Decomposition

- Results show decomposition of diglyme in as little as 3hrs at 95°C during reaction
- THP (tetrahydropyran) shows no decomposition after 24hrs during reaction at reflux (88°C)
- THP does not dissolve BH_4^- well and causes drastically different product observation

Reactant	Solvent	Reactant Concentration (M)	Time (hr)	Temperature (°C)	Results
Iodine	Diglyme	1.8	2	95	$B_3H_8^-$ cluster selective
	Diglyme	Solid	Rapid	95	Higher clusters, heavy side-products evident
	THP	Solid	Rapid	88	Higher clusters, few side products
Methyl Iodide	Diglyme	Neat	3-70	RT	No clusters formed, photodissociation of MeI
Pentyl Bromide	Diglyme	Neat	2	95	No $B_3H_8^-$ formation, excess formation of $B_2H_7^-$
	Diglyme	1.8	2	95	Small $B_3H_8^-$ formation
Copper (I) Chloride	Diglyme	Solid	Rapid	100	$B_3H_8^-$ formation, difficult workup due to metal deposition
	THP	Solid	Rapid	85	Higher borane clusters, no $B_3H_8^-$ formation
Copper (II) Sulfate	Water	Solid	1	95	Reduced metal deposition, no clusters, only borate product

Conclusions

- $B_3H_8^-$ can be synthesized in good yields from non-toxic precursory materials
- Kinetic issues need to be addressed
- Investigation into a new solvent with high BH_4^- solubility and low reactant solubility
- Better understanding of B^{11} NMR identification is needed for intermediate products

IRSA

Modulation of the Retinal Immune Environment in a Zebrafish System of Rod Photoreceptor-Specific Degeneration

University of Idaho

Zachary Blume and Diana Mitchell

Department of Biological Sciences, University of Idaho, Moscow, ID

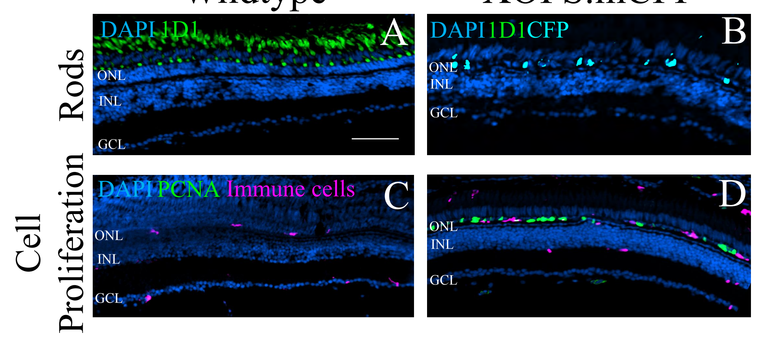
Abstract

Activated and pro-inflammatory microglia, along with accompanying local inflammation, are associated with human retinal degenerative disease. However, it remains unclear if these aspects of the immune response are symptomatic or directly initiate and/or contribute to disease pathology, such as the death of additional retinal neurons. One hypothesis for continued loss of neurons in retinal degenerative disease is that microglia may engulf, or possibly initiate cell death of, otherwise healthy neurons (1,2).

Our project attempts to test this hypothesis using a zebrafish system in which rod photoreceptors die due to a toxic transgene (XOPS:mCFP), but cone photoreceptors survive (3). We first characterized microglial characteristics in XOPS:mCFP retinas compared to wildtype and found that microglia localize to the photoreceptor layer and engulf dying rods, but total numbers of microglia are similar. Next, we successfully induced a pro-inflammatory retinal immune environment by intraocular injection of zymosan (a pro-inflammatory compound) (4), as indicated by our results showing infiltration and accumulation of immune cells in the retina and gene expression of selected transcripts.

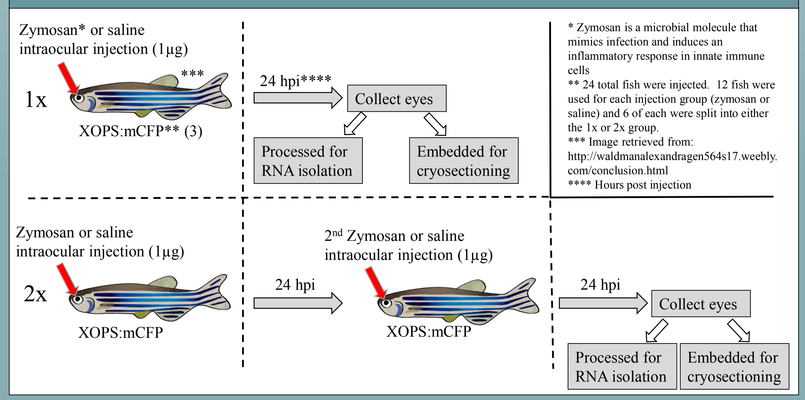
Our next goal is to determine if this induction of a pro-inflammatory retinal environment may result in subsequent cone death or disappearance in XOPS:mCFP retinas, thus directly probing contributions of a dysregulated immune environment to retinal degenerative disease.

Figure 1: Perpetual Rod Death and Regeneration in XOPS:mCFP Zebrafish Retinas



Images show a 5µm section of zebrafish retina from wildtype and XOPS:mCFP transgenic fish. Wildtype retinas (A,C) show healthy rods (A, labeled by 1D1) and lack of cell proliferation in the outer nuclear layer (ONL) (C, labeled by PCNA). XOPS:mCFP retinas (B,D) show far fewer rod photoceptors (B, labeled by CFP). 1D1 is not observed in XOPS:mCFP retinas because they do not express the protein rhodopsin (3), which is the 1D1 antibody target. We also observe a constant attempt to regenerate dying rods by proliferative rod precursors (D, labeled by PCNA). In XOPS:mCFP retinas, we also see that microglia localize to the ONL (similar to C) around the PCNA+ cells, but do not express PCNA themselves (D). This tells us that immune cells are not dividing in response to ongoing rod death, but instead the PCNA+ cells likely represent only rod precursors. Scale bar = 50µm and applies to all images. INL = inner nuclear layer, GCL = ganglion cell layer, PCNA = proliferating cell nuclear antigen.

Methods: Modulation of the Retinal Immune Environment



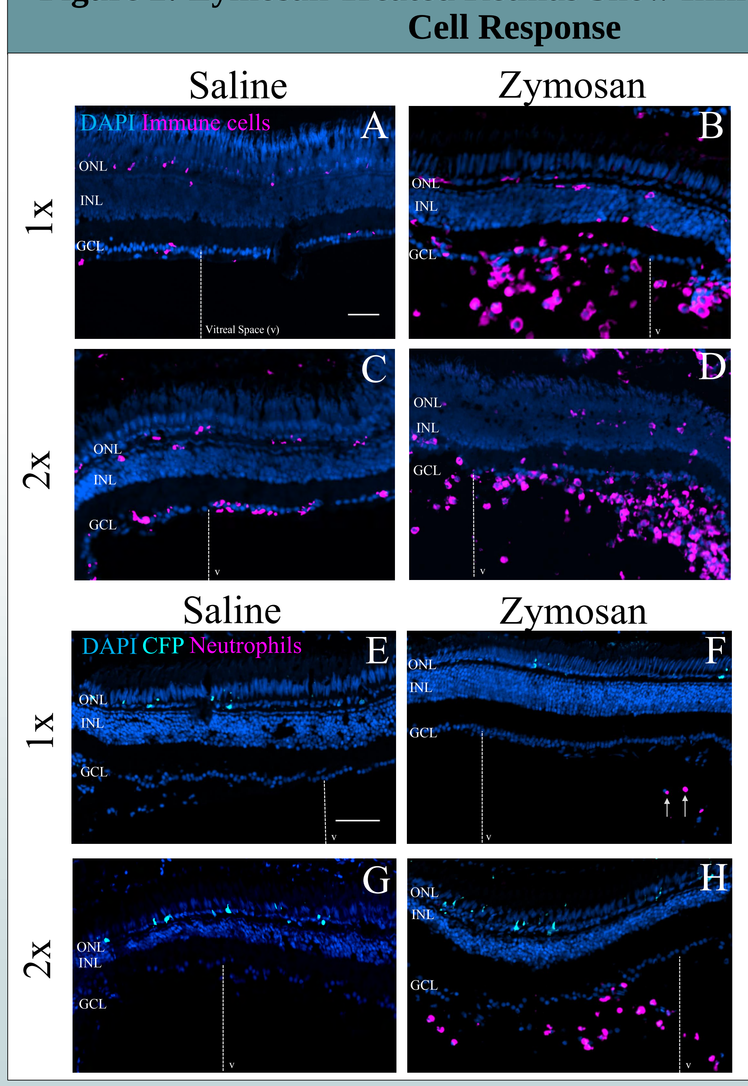
* Zymosan is a microbial molecule that mimics infection and induces an inflammatory response in innate immune cells

** 24 total fish were injected. 12 fish were used for each injection group (zymosan or saline) and 6 of each were split into either the 1x or 2x group.

*** Image retrieved from: http://waldmanalexandragen564s17.weebly.com/conclusion.html

**** Hours post injection

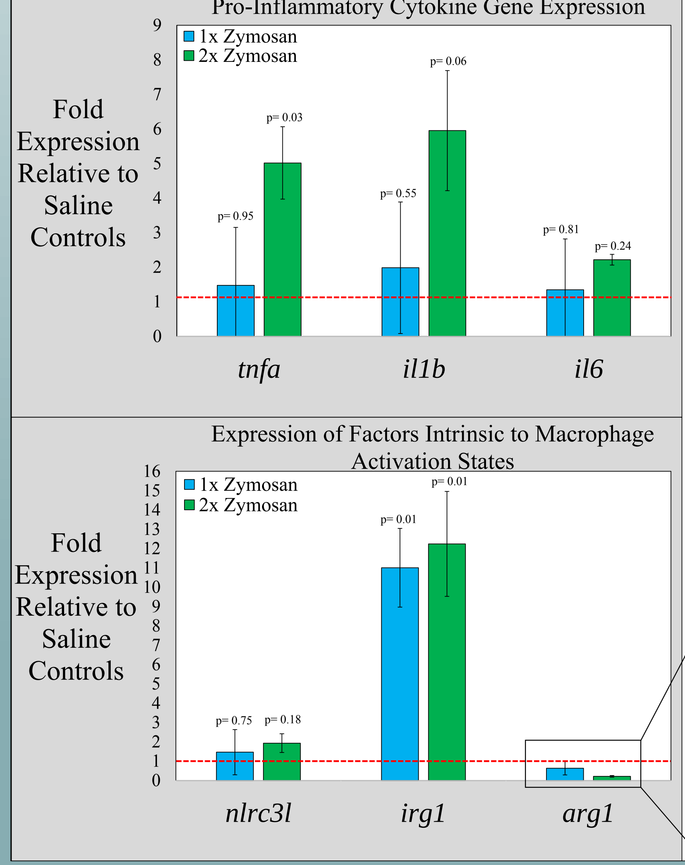
Figure 2: Zymosan Treated Retinas Show Infiltrating Immune Cell Response



Images show 5µm section of XOPS:mCFP retinas with 1x and 2x zymosan or saline (control) injections stained for L-plastin (immune cells, A-D) and MPX (neutrophils, E-H). After 1 injection of zymosan, immune cells infiltrate the retina which is shown by an accumulation of immune cells in the vitreal space (B) and redistribution of immune cells towards the GCL and vitreal interface. After 2 injections of zymosan, the immune cell population continued to increase (D). The immune cells that accumulate following zymosan injection include neutrophils, which is a characteristic of a pro-inflammatory response (arrows, F and H). However, the recruited neutrophils do not account for the entirety of the infiltrating immune cell population.

Scale bar = 50µm, A applies to B,C, and D. Scale bar in E applies to F,G, and H.

Figure 3: Increase in Pro-Inflammatory Gene Expression Following Zymosan Injection

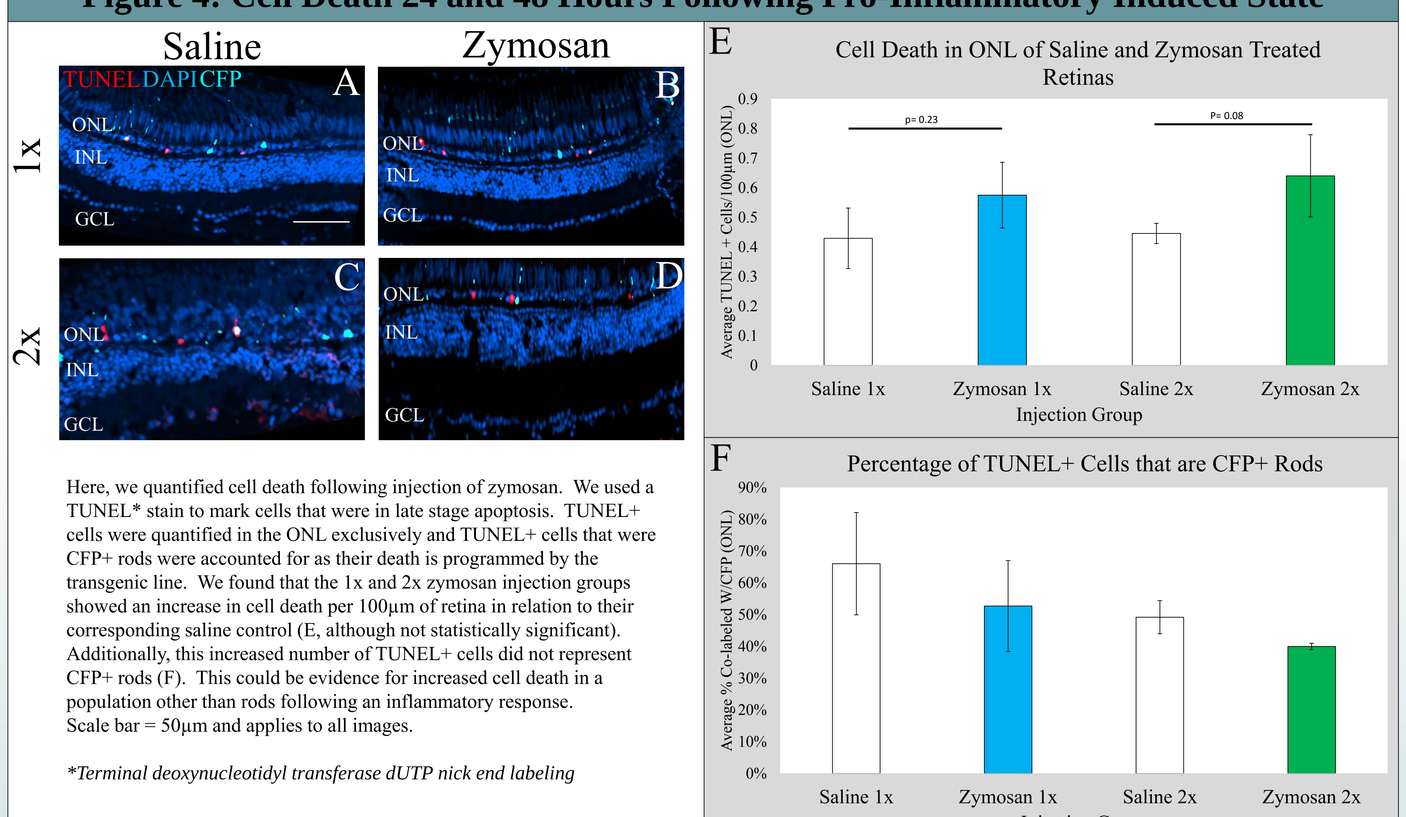


Quantitative PCR analysis of classic pro-inflammatory genes as well as genes that are specific to macrophage activation states. Gene expression was normalized using the housekeeping gene b-actin. The graph shows fold expression of selected genes where a value greater than 1 (designated by a red line on the graph) indicates elevated target gene expression, less than 1 indicates decreased target gene expression, and a fold change of 1 implies no change in gene expression.

tnfa, *il1b*, and *il6* are cytokines that are secreted by innate immune cells (including macrophages) to induce a state of inflammation (5).

nlrc3l, *irg1*, and *arg1* are all genes associated with different macrophage activation states. *nlrc3l* is a gene identified in zebrafish as an anti-inflammatory receptor (6). *irg1* is a gene induced by inflammatory stimuli and macrophage activation (7). And *arg1* is a macrophage gene that promotes wound repair (8).

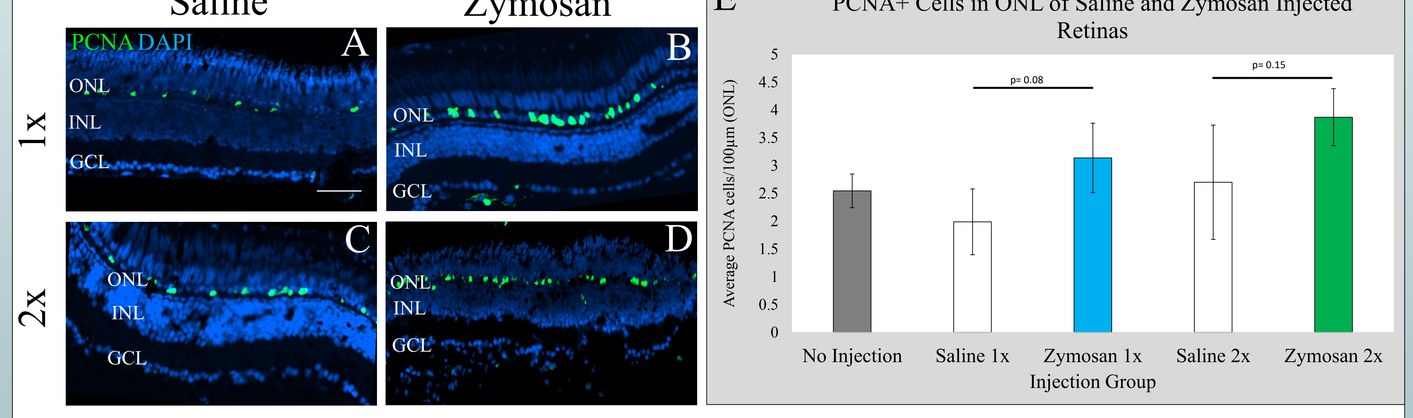
Figure 4: Cell Death 24 and 48 Hours Following Pro-Inflammatory Induced State



Here, we quantified cell death following injection of zymosan. We used a TUNEL* stain to mark cells that were in late stage apoptosis. TUNEL+ cells were quantified in the ONL exclusively and TUNEL+ cells that were CFP+ rods were accounted for as their death is programmed by the transgenic line. We found that the 1x and 2x zymosan injection groups showed an increase in cell death per 100µm of retina in relation to their corresponding saline control (E, although not statistically significant). Additionally, this increased number of TUNEL+ cells did not represent CFP+ rods (F). This could be evidence for increased cell death in a population other than rods following an inflammatory response.
Scale bar = 50µm and applies to all images.

**Terminal deoxynucleotidyl transferase dUTP nick end labeling*

Figure 5: Cell Proliferation 24 and 48 Hours Following Pro-Inflammatory Induced State



Images show 5µm section of XOPS:mCFP retinas with 1x and 2x zymosan or saline (control) injections stained for PCNA to indicate cell proliferation. PCNA+ cells were quantified in the ONL exclusively. We found that the1x and 2x zymosan injection groups had more PCNA+ cells per 100µm of retina when compared to their corresponding saline control (E). XOPS:mCFP eyes that did not receive an injection were also quantified as a control. We found that the zymosan treated eyes had an increased number of PCNA+ cells when compared to eyes receiving no injection, but was not statistically significant (p= 0.70, 1x) (p= 0.18, 2x). Both groups of saline injected controls showed no significant change when compared to eyes receiving no injection (p= 0.03, 1x) (p= 0.38, 2x). We observed that only rarely were L-plastin+ cells also PCNA+ (not shown) indicating that immune cells in the ONL did not represent significant numbers of the PCNA+ cells quantified. Scale bar = 50µm and applies to all images.

Conclusions and Future Directions

- We have shown that we can induce an inflammatory response in the zebrafish retina by using the microbial compound zymosan to mimic infection. Resident and infiltrating immune cells mount an inflammatory response as early as 24 hpi and continue to infiltrate up to 48 hpi. Along with infiltrating immune cells characteristic of an inflammatory response, we observed an increase in gene expression for target genes that are indicative of a pro-inflammatory state of macrophage activation.
- In 1x and 2x zymosan injected XOPS:mCFP retinas, TUNEL+ and PCNA+ cells were slightly more numerous than in saline injected controls (although differences were not statistically significant). Also, less cell death appeared to be attributed to CFP+ rods in the zymosan injected retinas.
- The future of this project will be to determine if sustained inflammation (for longer periods) in the retinal microenvironment may result in subsequent cone death, other other signs of pathology, in XOPS:mCFP retinas, more akin to simulating a chronic degenerative disease. Moving forward we hope to directly probe the contributions of a dysregulated immune environment to retinal degenerative disease.

Acknowledgements

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I would like to thank all members of the Mitchell and Stenkamp lab for their technical assistance, discussion, and guidance; Ann Norton, IBEST OIC; Dr. Ann Morris (University of Kentucky) for providing the XOPS:mCFP zebrafish line; Dr. Michael Redd (University of Utah) for providing the L-plastin antibody; and Dr. James Fadool (Florida State University) for providing the 1D1 antibody.

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TAB 3 Page 55

ATTACHMENT 5

INSTRUCTION, RESEARCH, AND STUDENT AFFAIRS
JUNE 19, 2019

Computing Fourier Coefficients of Siegel Modular Forms

Beau Horenberger

Fourier Expansions

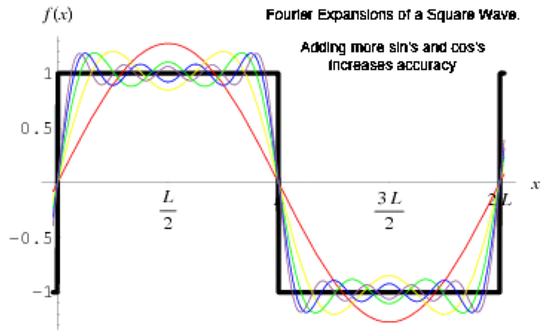
Fourier expansions are a method of writing a periodic function, s(x), as a sum of other, simpler functions: sin and cosine waves. One way to write this representation is

$$f(x)=\sum_{n=0}^{\infty}A_n\cos\left(\frac{n\pi x}{L}\right)+\sum_{n=1}^{\infty}B_n\sin\left(\frac{n\pi x}{L}\right)$$

Though this can be condensed as

$$f(x)=\sum_{n=1}^{\infty}c_n e^{i\frac{2\pi nx}{P}}$$

The following is a set of approximations using the first k terms of a Fourier expansion:



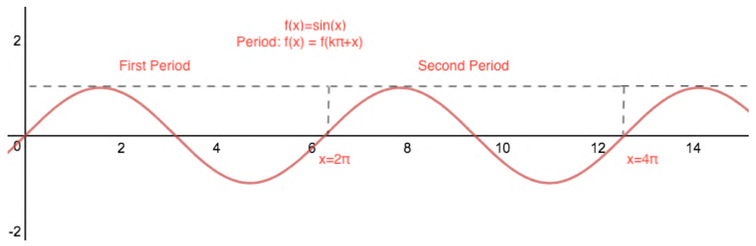
Fourier expansions are a valuable method for analyzing the behavior of functions. The coefficients c_n are determined via

$$c_n=\frac{1}{P}\int_{x_0}^{x_0+P}s(x)\cdot e^{-i\frac{2\pi nx}{P}}\,dx,$$

Where s(x) is the original function. These coefficients contain information about the original function and are relevant in the analysis of modular and Siegel modular forms.

What Are Modular Forms?

Modular forms are complex-valued forms with a kind of periodicity, because of which they can be approximated via Fourier series or polynomials.
Traditional periodicity is illustrated below:



Rather than a period P and the relation $f(x)=f(kP+x)$, a modular form of weight k has the following relation:

$f\left(\frac{az+b}{cz+d}\right)=(cz+d)^k f(z)$ for all matrices $\det\begin{pmatrix}a & b\\ c & d\end{pmatrix}=1$

With *a,b,c,d* being integers.

Notice that if we have the matrix $\begin{pmatrix}1 & 1\\ 0 & 1\end{pmatrix}$, our equation becomes

$$f(z+1)=f(z)$$

And if we have the matrix $\begin{pmatrix}0 & 1\\ -1 & 0\end{pmatrix}$, it becomes

$$f\left(\frac{-1}{z}\right)=z^k f(z)$$

In fact, these two matrices are sufficient to generate all matrices of determinant 1 and describe the underlying actions at work in the set of matrices.
The theory of modular forms has been relevant in many Number Theory proofs as well as in the theory of elliptic curves. An example is Jacobi's 4-Square Theorem, which describes the number of ways an integer can be written as the sum of four squares:

$$\left(\sum_{n=-\infty}^{\infty}q^{n^2}\right)^4=\sum_{a,b,c,d\in\mathbf{Z}}q^{a^2+b^2+c^2+d^2}=1+8\sum_{m=1}^{\infty}\sum_{\substack{d\mid m\\ 4\nmid d}}dq^m.$$

Binary Quadratic Forms

Binary quadratic forms with discriminant *N* are expressions of the form

$$f(x,y)=ax^2+bxy+cy^2, where\ b^2-4ac=N$$

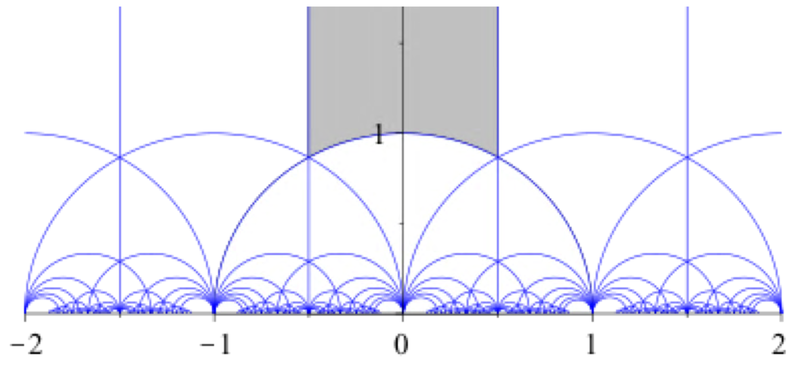
Two binary quadratic forms, *f(x,y)* and *g(x,y),* are properly equivalent if there exists a transformation $\begin{pmatrix}a & b\\ c & d\end{pmatrix}$ with determinant 1 such that

$$f(ax+by,cx+dy)=g(x,y)$$

This means properly equivalent binary quadratic forms represent the same values.
Binary quadratic forms of negative discriminant *N* are always equivalent to exactly one reduced form, where

$$b\le a\le c, where\ b\ge 0\ if\ |b|=a$$

And a similar circumstance applies to positive discriminants.
There are a finite number of reduced forms, and thus, it can be shown that binary quadratic forms of a discriminant *N* can be broken into a finite number of equivalence classes.
The set of reduced forms can be used to reach all other forms via transformation, and thus are valuable for representation purposes. We consider this the "fundamental domain" of binary quadratic forms. The fundamental domain for transformations of the form $\begin{pmatrix}a & b\\ c & d\end{pmatrix}$ with $\det\begin{pmatrix}a & b\\ c & d\end{pmatrix}=1$ is shown here to give a visual representation of the concept.



Siegel Modular Forms

Siegel modular forms are similar to modular forms, but instead use complex matrices. Siegel modular forms have a level, *N,* weight, ρ, and degree (or genus), g.
They can be generated through the use of a series, such as the Eisentein series.
As an example, we consider the Siegel modular form of weight 24, level 4, and degree 1 which has an explicit formula:

$$78*A^2*B*C-67*A^3*D-274492800*A*C^2+25*B^2*D+71539200*D^2$$

Where $\begin{pmatrix}A & B\\ C & D\end{pmatrix}$ is in $\Gamma_g(N)$, the symplectic group of level *N*, defined as

$$\Gamma_g(N)=\left\{\gamma\in GL_{2g}(\mathbb{Z})\mid \gamma^{\mathrm{T}}\begin{pmatrix}0 & I_g\\ -I_g & 0\end{pmatrix}\gamma=\begin{pmatrix}0 & I_g\\ -I_g & 0\end{pmatrix},\ \gamma\equiv I_{2g}\mod N\right\}$$

Sample coefficients of the Fourier expansion include: -576, -72864, and -722304
One kind of modular form, the Siegel paramodular form, uses only an arithmetic subgroup of the symplectic group. These Siegel paramodular forms have a Fourier expansion:

$$f(Z)=\sum_{T\epsilon A(N)^+}a(T)e^{2\pi itr(TZ)}$$

However, notice the index set of the sum is not in the integers. Instead, they are binary quadratic forms *S* such that:

$$S=\begin{bmatrix}\alpha & \beta\\ \beta & \gamma\end{bmatrix},\quad \alpha\in N\mathbb{Z},\quad \gamma\in\mathbb{Z},\quad \beta\in\frac{1}{2}\mathbb{Z},\quad \alpha>0,\quad \det\begin{bmatrix}\alpha & \beta\\ \beta & \gamma\end{bmatrix}=\alpha\gamma-\beta^2>0$$

This is a matrix representation of the binary quadratic forms $\alpha x^2+2\beta xy+\gamma y^2$ meeting the described conditions.
Thus, analyzing the Siegel paramodular form's Fourier coefficients requires an understanding of binary quadratic forms and the values they can represent

Computing New Siegel Modular Forms

It has been proven that given a Siegel paramodular form (particularly a Siegel cusp form of paramodular level *N*, weight *k*, and degree 2) can be twisted to create a new Siegel modular form of level Np^4 with a Fourier expansion:

$$\mathcal{T}_\chi(f)(Z)=\sum_{T\epsilon A(N)^+}W(\chi)a_\chi(T)e^{2\pi itr(TZ)}$$

Where $W(\chi)$ and $\alpha_\chi(T)$ are described in *Fourier Coefficients For Twists Of Siegel Paramodular Forms (Expanded Version)* , and χ is the Dirichlet character mod *p*.
The definition of $W(\chi)$ and $\alpha_\chi(T)$ involves many computations with binary quadratic forms, necessitating theory of binary quadratic forms for analysis of the Fourier coefficients, such as what values they can represent.

Goals of Research

The goal of this research is to create a code base which can compute equivalence classes and properties of represented values for binary quadratic in order to generate and analyze new Siegel modular forms and their Fourier coefficients. For example, once sufficient conditions were proven, the following code was created to generate representatives of the equivalence classes of binary quadratic forms in the simplest case:

```
int main(){

  //Gets the discriminant from the user
  cout << "Input discriminant (negative numbers only):\n";
  int d;
  cin >> d;

  //This first loop identifies possible a values
  for(long int a = 1; a <= sqrt(float(-1*d)/3.0); a++)
    {
      //Identifies possible b values
      for(long int b = -a; b <= a; b++)
        {
          //Solves for c, then checks whether a,b,c work
          long int c = (d-(b*b))/(-4*a);
          //Checks they sum to D, checks gcd, and then ensures they meet the definiti\
on of reduced
          if(b*b-(4*a*c) == d && gcd(a,gcd(b,c))==1)
            {
              if(((abs(b)!=a && a!=c) || b>=0) && (abs(b)<=a && a<=c))
                {
                  addForm(a, b, c);
                }
            }
        }
    }
  //counts and prints the forms (not in that order)
  printForms();
  cout << "h(D)=" << countForms() << endl;

}
```

Additionally, further partitions of binary quadratic forms have been identified and computed based on stricter definitions of equivalence.
This code base will be able to twist Siegel paramodular forms using the described $W(\chi)$ and $\alpha_\chi(T)$ and analyze the resulting form's Fourier coefficients. Any new forms will then be added to databases of Siegel modular forms, such as LFMDB.

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Image Sources

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Acknowledgements

Thanks to my mentor, Dr. Jennifer Johnson-Leung for keeping me on track and optimistic, Daniel Reiss for his insightful advice, and the University of Idaho and the SURF program for making this possible.

Determining the Benefit Human Cytomegalovirus Gains by Down Regulating the Basement Membrane Protein Nidogen-1

Hannah Jaeger, Elizabeth Fortunato, John O'Dowd
Department of Biological Sciences

Introduction

- Human cytomegalovirus (HCMV) infects one percent of newborns annually
- 10% of these infants show CNS/PNS defects at birth and another 10% develop problems in the first 5 years of life
- Mother–child transmission of HCMV is mainly the result of primary (first exposure) maternal HCMV infection
- HCMV is able to pass through the human umbilical vein endothelial cells (HUVEC) and infect the fetus during an infection, which is uncommon for other viral infections
- HCMV uses tegument proteins to target the downregulation of nidogen 1 (NID1)
- Multiple resources are used by the virus to downregulate NID1 indicating some benefit is derived

Background

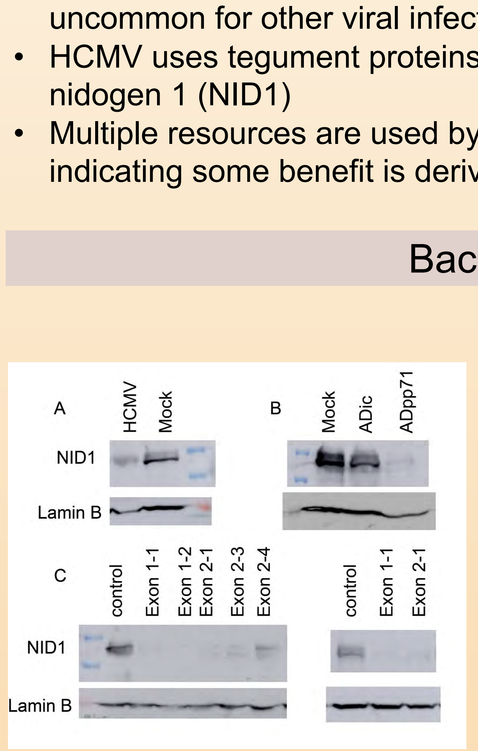

Figure 1: (A) HUVECs were mock- or virus infected at an MOI=20 and harvested 96 hpi for Western blot analysis. (B) HUVECs were infected with ADic or ADpp71 at MOI=10 and harvested at 48 hpi for Western blot analysis. (C) HFFs (left) or HUVECs (right) were transduced with 1 of 5 NID1 KO CRISPR lentiviruses, then pools were selected with puromycin, seeded at an equal density and harvested 72 hp plating for Western blot analysis for NID1.

Objective and Hypothesis

Our overall objective is to elucidate the benefit that HCMV derives from targeting NID1. A series of experiments listed below will test the hypothesis that HCMV uses NID1 downregulation to promote dispersal of infected cells via remodeling of the ECM in infected blood vessels.

Methods

We will test five different treatments of the HUVEC monolayers in order to determine the benefit of targeting NID1: 1) HPV immortalized HUVECs (control/baseline migration), 2) CRISPR NID1 KO HUVECs (to determine the effect of just NID1 knockdown), 3) control CRISPR-treated HUVECs, 4) HCMV-pp71 expressing HUVECs (AD-pp71) (which should knockdown NID1 but may change other additional aspects) and 5) HUVECs infected with full infection of HCMV as well as a mock infection for comparison. HUVECs stably infected with HPV were used for all treatments.

Transmigration Assay

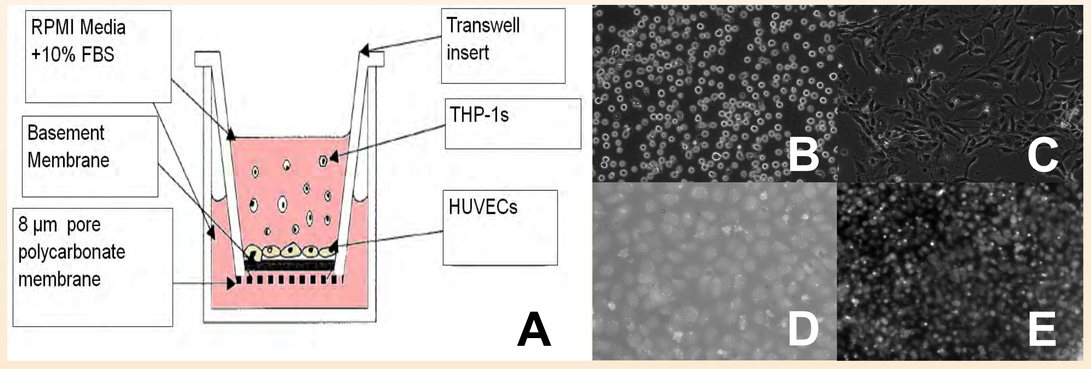

Figure 2. Schematic Diagram of Transmigration Assay and developed Monolayers. *A,* THP-1 monocytic cells were utilized due to their ability to migrate well through the transwell membrane. HUVECs from all four treatments were seeded in triplicate at a density of 1.5 x 10^4 cells in 200 µl of endothelial media onto transwell filters (8 µm pore size) with 600 µl of media in the bottom and allowed to grow to confluence for 8 days. Once confluent, 5 x 10^5 THP-1 cells will be seeded onto the transwell inserts on top of the HUVEC monolayer in 200 µl of RPMI media +FBS. Migration counts were recorded using a hemocytometer at 24 and 48 hours. *B,* THP1 cells, *c,* HUVECs, *d,* HUVEC monolayer in 96 well plate, and *e,* HUVEC monolayer on transwell insert stained with Calcein. All images were taken using a 10X objective.

Development of CRISPR HUVECs

Figure 3. Schematic Diagram of Single cloning technique. HUVECs were infected with either a NID1 knock down or an off target CRISPR construct that does not affect any basement membrane proteins. Single cloning was performed and then colonies were analyzed for NID1 levels.

HCMV/ADpp71 Infections of HUVEC Monolayers

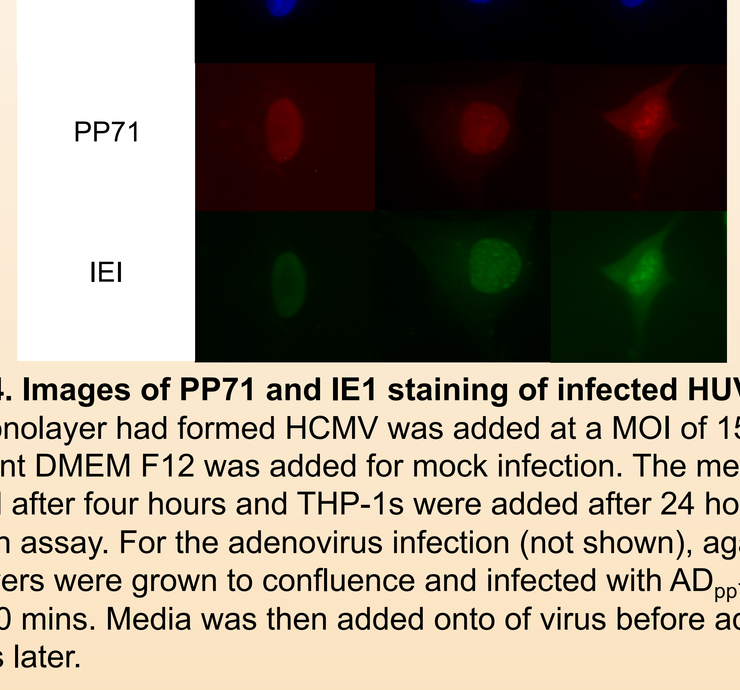

Figure 4. Images of PP71 and IE1 staining of infected HUVECs. Once each monolayer had formed HCMV was added at a MOI of 15 and equivalent DMEM F12 was added for mock infection. The media was changed after four hours and THP-1s were added after 24 hours for the migration assay. For the adenovirus infection (not shown), again monolayers were grown to confluence and infected with AD_{pp71} or AD_{ic} at RT for 30 mins. Media was then added onto of virus before adding THP1s 24 hours later.

Results

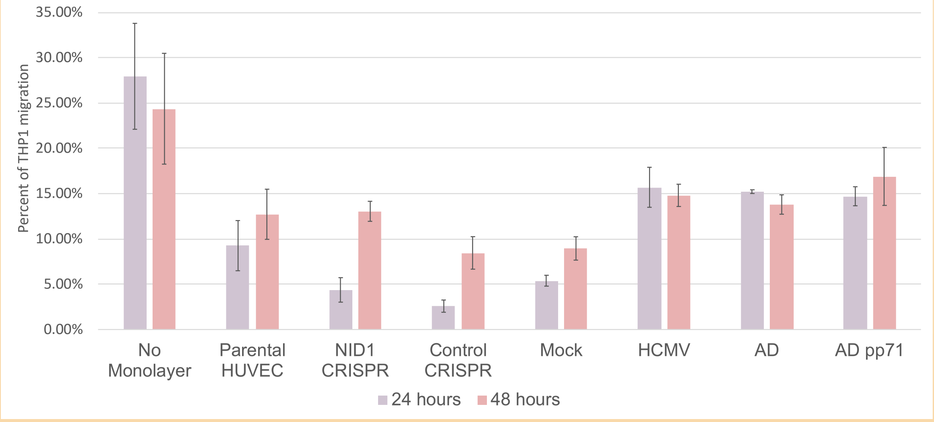

Figure 5. Preliminary data of transwell assay. 12 different transwells covering five different experiments for both the parental HUVECs and no monolayer present, 4 transwells in one experiment for both CRISPR constructs, and 2 transwells in one experiment for the HCMV infections and AD infections were tested.

Conclusion and Future directions

Multiple resources are used by the virus to downregulate NID1 indicating some benefit is derived. We know through these preliminary results that the presence of low amounts of NID1 in the CRIPRS pools had similar migration rates as the parental strand, indicating that even a small amount of NID1 helps to uphold the integrity of the monolayer. We also confirmed that a full infection increases migration compared to the mock without decreasing monolayer integrity. Decreased monolayer integrity in the adenovirus infections indicates troubleshooting for future experiments.

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Acknowledgements

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Live Imaging to Probe the Role of Microglia in Developmental Apoptosis in the Zebrafish Retina

University of Idaho

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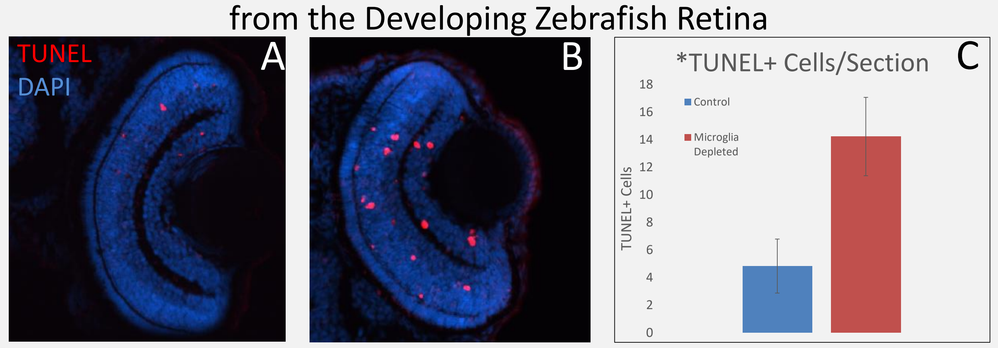
Abstract

During mammalian retinal development, programmed cell death (apoptosis) occurs in large waves in a spatio-temporal fashion to generate functional retinas. In zebrafish comparably smaller waves have been observed and are thought to represent fine-tuning of developing retinal tissue (Biehlmaier 2001). It is appreciated that tissue resident macrophages clear apoptotic cells (Hochreiter-Hufford 2013), however, specific roles for microglia in cell survival/death and clearance during retinal development in zebrafish have not been documented. We used an inducible system to specifically deplete macrophages/microglia during retinal development (Petrie 2015) and found an increased number of apoptotic cells in the retina compared to controls. This finding suggests that microglia clear larger numbers of apoptotic cells than is currently appreciated, or alternatively, that microglia provide survival signals to developing retinal cells. To address clearance of apoptotic cells during zebrafish retinal development in real-time, we live imaged fluorescently labeled retinal microglia together with apoptotic cells using acridine orange (AO). We observed that microglia sense and engulf cells prior to AO incorporation, and that engulfed apoptotic cells undergo dynamic movements as microglia continue active migration. This suggests that apoptotic cells visualized in fixed tissues using AO may not represent true levels of apoptosis and their retinal locations may differ from where apoptosis was initiated.

Background

Figure 1. Increase in Apoptotic Cells When Micrgolia are Depleted from the Developing Zebrafish Retina

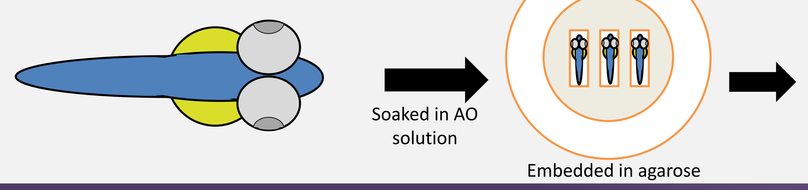


Cryosections from control (A) zebrafish retinas (10 µm thickness) or those depleted of microglia (B) were stained for TUNEL* (red) and DAPI (blue). Retinas with depleted microglia show an increased number of TUNEL+ cells than that of control eyes (C).

*TUNEL stands for Tdt-mediated dUTP Nick End Labeling, and is used to label apoptotic cells undergoing DNA fragmentation.

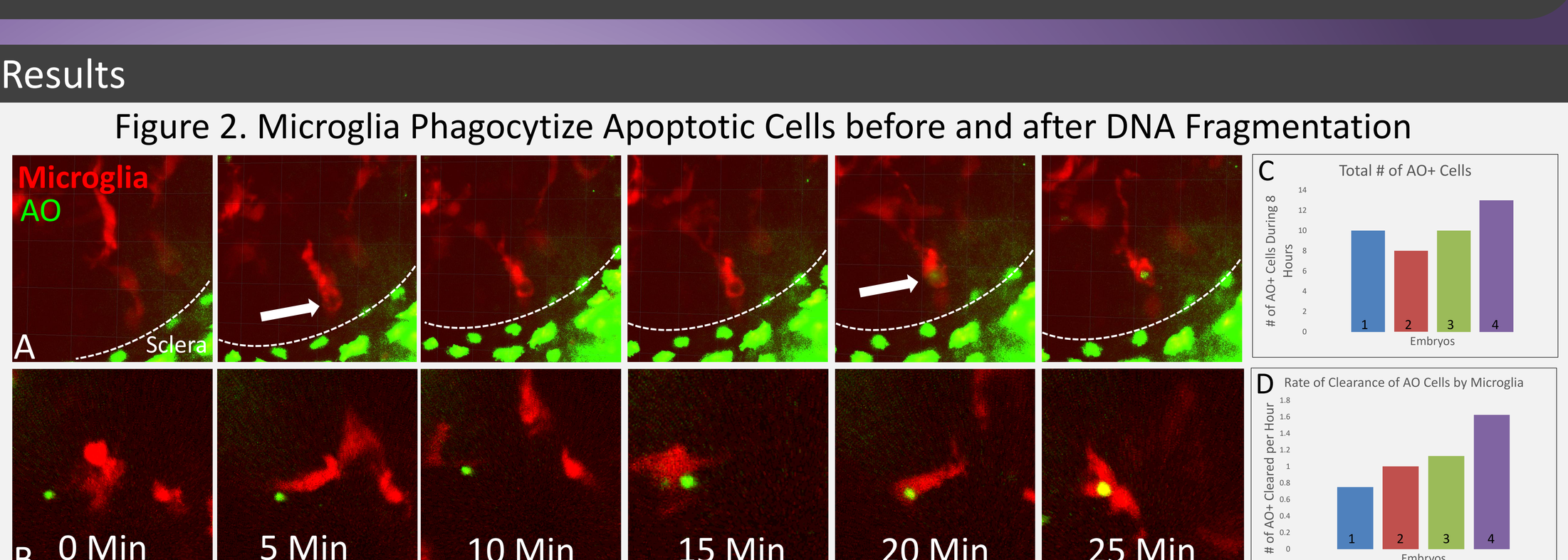
Methods

- The zebrafish line Tg(*mpeg1*:mCherry) was used to visualize microglia through fluorescent microscopy, as it expresses a red fluorescent marker in macrophages.
- Embryos were soaked in Acridine Orange (AO) prior to imaging, which binds to fragmented DNA in late stage apoptotic cells and is visualized through fluorescent microscopy.
- Embryos were immobilized with tricaine then embedded in 2% agarose overlayed with 1% agarose. The agarose was then covered with an AO/tricaine/water solution, allowing us to visualize apoptotic cells appearing during imaging, as well as keeping the fish immobilized and alive.
- Embryo Eyes were imaged on a Nikon Spinning Disk Confocal Microscope every 5 min. for a duration of 8 hours, starting at 52 hours post fertilization (hpf) or ~2 ½ Days Post Fertilization (dpf).
- Z-stacks were obtained at each timepoint, with each stack measuring 5 microns in order to follow microglia and AO+ cells in 4 dimensions.



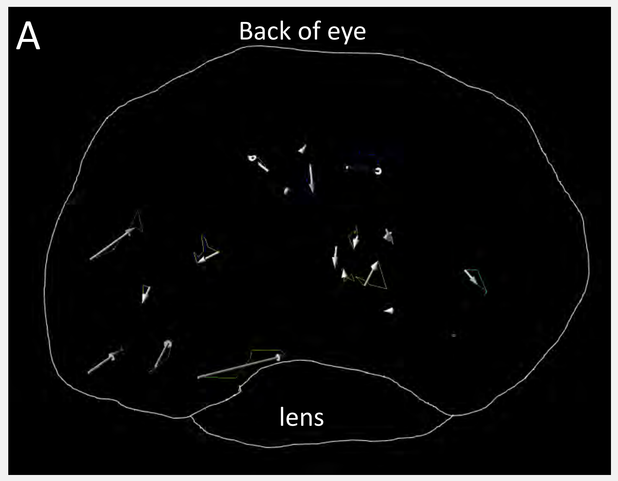
Results

Figure 2. Microglia Phagocytize Apoptotic Cells before and after DNA Fragmentation

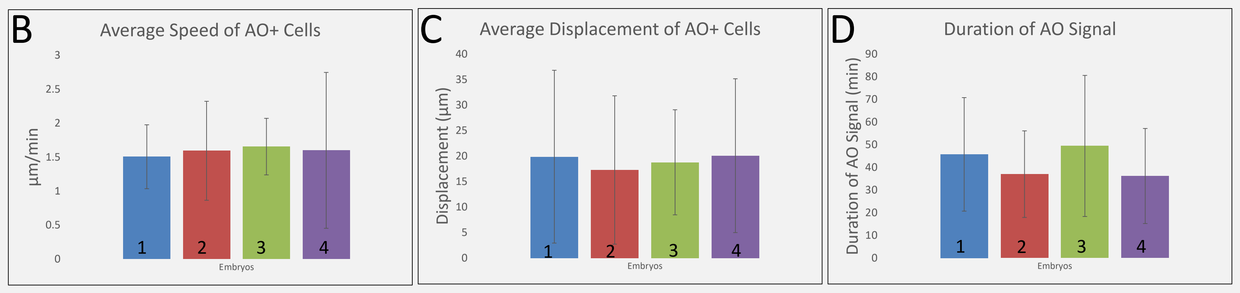


Apoptotic cells are cleared by microglial phagocytosis, which can occur before (A) or after (B) DNA fragmentation. Most of the time, AO+ signal appears after phagosome formation (shown by arrows) as shown in A. The total # of AO+ cells over 8 hours (C). Clearance rate of AO cells over the 8 hour imaging period (D).

Figure 3. Displacement of AO+ Cells



AO+ apoptotic cells were displaced from their original position after being engulfed by microglia, and disappear in different positions than when they were first phagocytized (A). AO+ cells moved around at a speed consistent with documented microglial speeds (Morsch 2015) (B). AO+ Cells are displaced from their original position as microglia continue to move about the retina (C). The AO+ cells remain visible for ~20-80 minutes, until they are broken down inside of microglia, likely in the lysozomes (D).



Conclusions and Future Directions

Microglia are actively involved in clearing apoptotic cells from developing zebrafish retinas. Most of the time, microglia sense and engulf apoptotic cells prior to DNA fragmentation.

After engulfing AO+ cells, microglia continue to move about the retina, carrying the apoptotic cells with them. Apoptotic cells are digested by microglia as they move about, and completely degenerate in a location different than their generation.

Our next steps will be to (i) inhibit phagocytosis and (ii) inhibit cell death to see if there is an equivalent increase in apoptotic cells. We will also image with early apoptotic markers to visualize engulfment of cells in earlier stages of apoptosis.

The combined results of these studies will allow us to determine more accurate rates of programmed cell death during retinal development in zebrafish and also determine if microglia may provide survival signals to developing retinal neurons.

Acknowledgements

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Ann Norton and Onesmo Balemba, University of Idaho IBEST OIC;
Ruth Frey, (Stenkamp lab) for technical assistance and zebrafish care;
and Dr. Deborah Stenkamp for helpful review of our data.
The Tg(*mpeg1*:mCherry) line was obtains from ZIRC.

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Ionic and Biomolecular Movement Through Functionalized Thin Filmed Polymers

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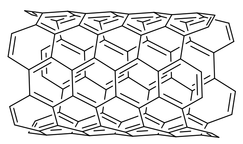
Abstract

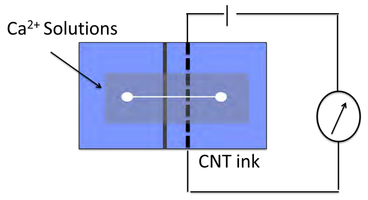
Ions and biomolecules are essential for many functions of the human body such as bone strength and development, muscle contractions, and cell functions like membrane transport and membrane potentials. This experiment will use post-polymerization functionalization to bind to Calcium ions (Ca^{2+}), using ion selective electrode polymers, this binding could be a way of monitoring calcium levels in the body. The polymer scaffolding will be made from Poly-(3-sulfopropyl methacrylate). This sulfonic acid polymer will capture Ca^{2+} through negatively charged terminal ends, in acidic environments, that can ionically bond to the Ca^{2+}. These polymers will be grown on carbon nanotubes. We will characterize these polymers with transmission electron microscopy (TEM) and RAMEN spectroscopy. The transport of Ca^{2+} through the polymer surfaces will be monitored by measuring the voltage change on the polymer electrode as a Calcium solution is passed over it. A device was engineered to hold the polymer in a closed system to allow the solution to pass over it and out, which allows us to monitor the concentration of the calcium solution after polymer interaction.

Background

Carbon nanotubes (CNTs) are conductive and can be printed onto surfaces to serve as a reliable sensor. They can also serve as a surface for polymerization to directly sense Ca^{2+} ions.

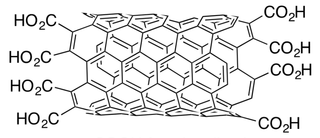


MW-CNT



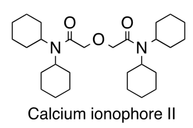
Nanotube inks can be mixed with calcium ionophore to have reliable calcium sensing. Monomers can also be synthesized to act as the ionophore in the solution when they are polymerized onto the carbon nanotubes. The inks cocktails are drop casted onto the device with a reference electrode to make an ion selective electrode. Where the voltage can be measured while running a calcium solution through the device.

Nink 1000



COOH functionalized MWCNTs
plus SDS in Water

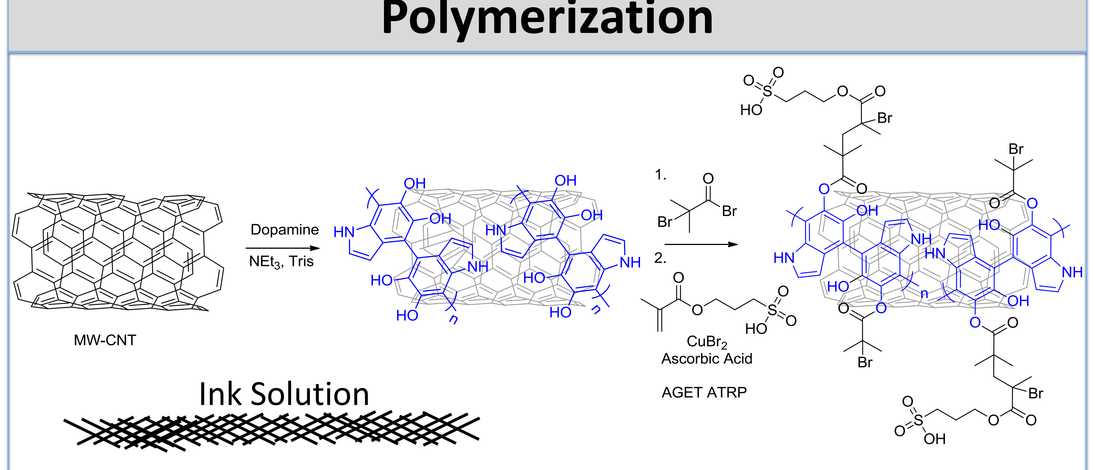
Calcium Ionophore Cocktails



Calcium ionophore II

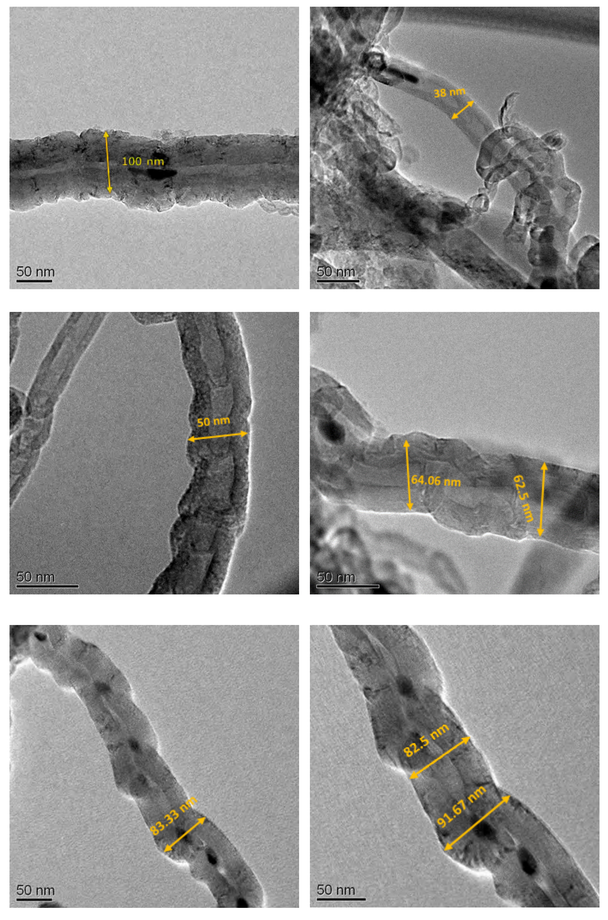
plus Sodium tetraphenylborate o-Nitrophenyl octyl ether in THF solution

Polymerization



Multi-walled Carbon nanotubes are reacted with dopamine to coat the nanotubes in polydopamine (PDA). Then they are reacted with BIBB which acts as the initiator for the polymerization to add 3-sulfopropyl methacrylate to the end of the CNT. These nanotubes were added to an ink solution and drop casted onto a glass slide to make an ion selective electrode.

Transmission Electron Microscopy

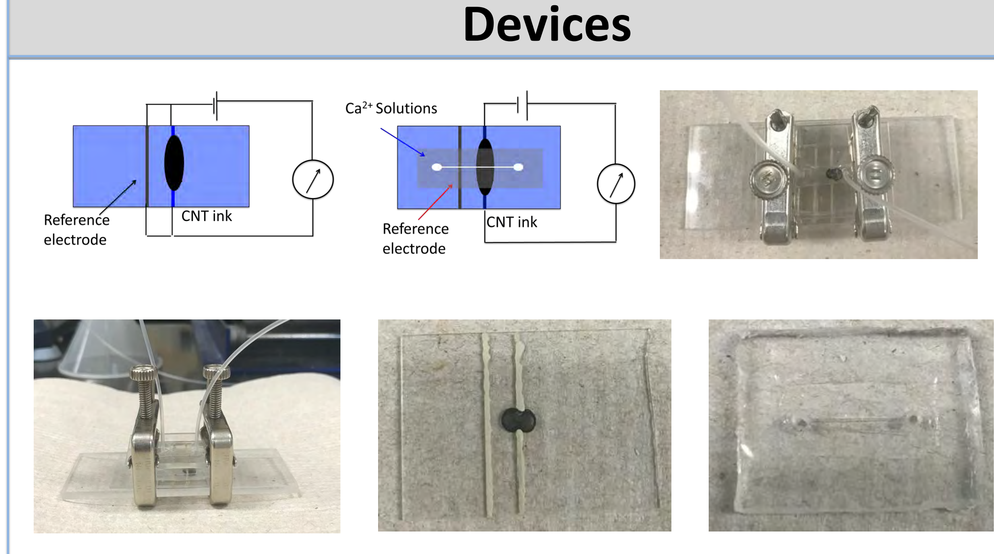


CNT (Starting Material)
Average Diameter ~40 nm

CNT-PDA
Average Diameter ~55 nm

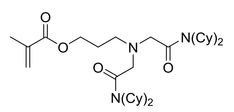
CNT-PDA-BIBB
Average Diameter ~80 nm

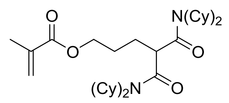
Devices



Future Work

- Different Monomers
  - Iminodiacetic acid
  - Malonic Acid





- Printing inks onto devices with a printer
- Determining if the inks are ion selective

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Acknowledgements

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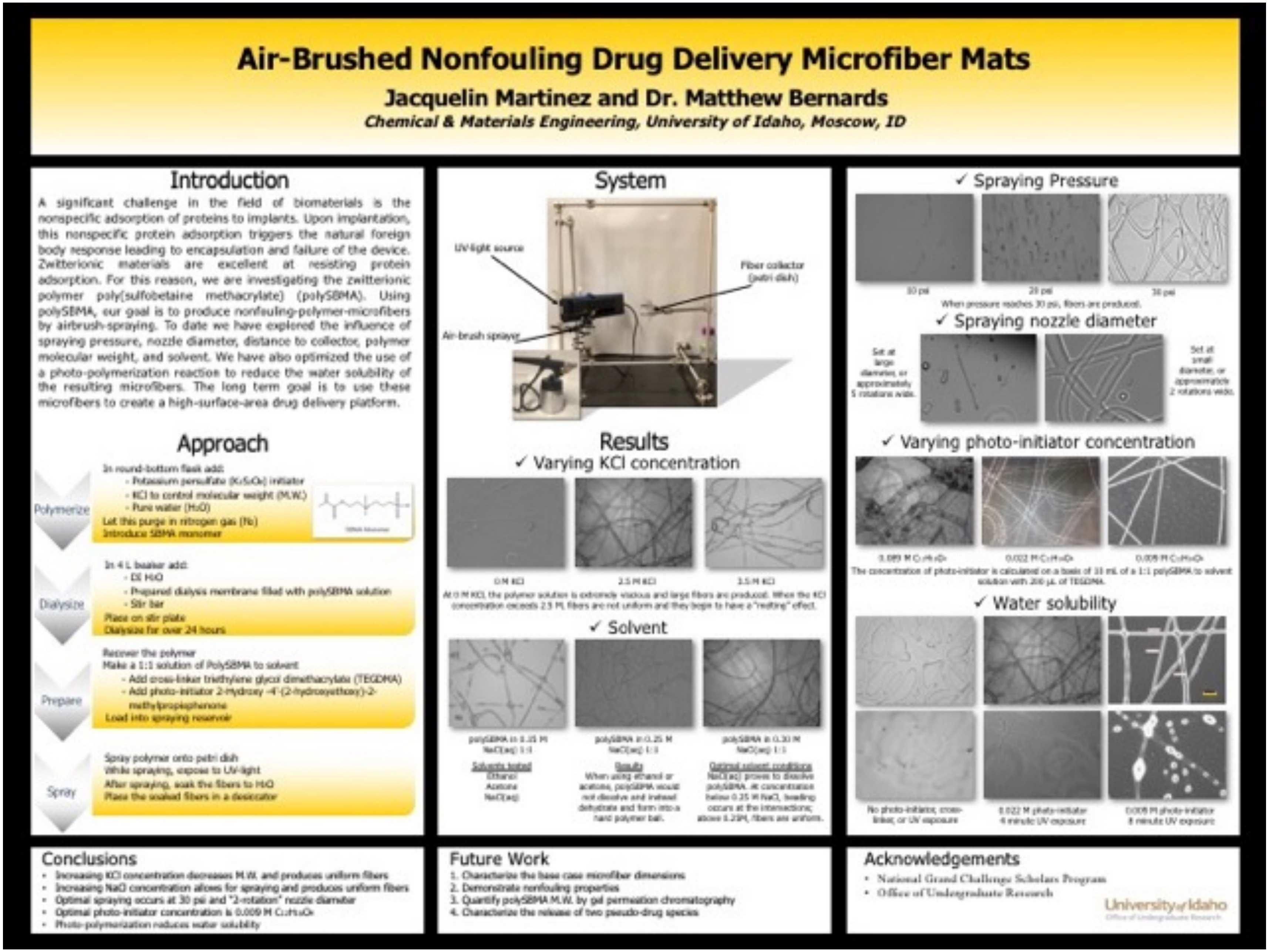
Air-Brushed Nonfouling Drug Delivery Microfiber Mats
Jacquelin Martinez and Dr. Matthew Bernards
Chemical & Materials Engineering, University of Idaho, Moscow, ID
Introduction
A significant challenge in the field of biomaterials is the nonspecific adsorption of proteins to implants. Upon implantation, this nonspecific protein adsorption triggers the natural foreign body response leading to encapsulation and failure of the device. Zwitterionic materials are excellent at resisting protein adsorption. For this reason, we are investigating the zwitterionic polymer poly(sulfobetaine methacrylate) (polySBMA). Using polySBMA, our goal is to produce nonfouling-polymer-microfibers by airbrush-spraying. To date we have explored the influence of spraying pressure, nozzle diameter, distance to collector, polymer molecular weight, and solvent. We have also optimized the use of a photo-polymerization reaction to reduce the water solubility of the resulting microfibers. The long term goal is to use these microfibers to create a high-surface-area drug delivery platform.
Approach
Polymerize
In round-bottom flask add:
- Potassium persulfate ($K_2S_2O_8$) initiator
- KCl to control molecular weight (M.W.)
- Pure water (H_2O)
Let this purge in nitrogen gas (N_2)
Introduce SBMA monomer
Dialysize
In 4 L beaker add:
- DI H_2O
- Prepared dialysis membrane filled with polySBMA solution
- Stir bar
Place on stir plate
Dialysize for over 24 hours
Prepare
Recover the polymer
Make a 1:1 solution of PolySBMA to solvent
- Add cross-linker triethylene glycol dimethacrylate (TEGDMA)
- Add photo-initiator 2-Hydroxy-4'-(2-hydroxyethoxy)-2-methylpropiophenone
Load into spraying reservoir
Spray
Spray polymer onto petri dish
While spraying, expose to UV-light
After spraying, soak the fibers to H_2O
Place the soaked fibers in a desiccator
System
UV-light source
Fiber collector (petri dish)
Air-brush sprayer
Results
✓ Varying KCl concentration
0 M KCl
2.5 M KCl
3.5 M KCl
At 0 M KCl, the polymer solution is extremely viscous and large fibers are produced. When the KCl concentration exceeds 2.5 M, fibers are not uniform and they begin to have a "melting" effect.
✓ Solvent
polySBMA in 0.15 M NaCl(aq) 1:1
polySBMA in 0.25 M NaCl(aq) 1:1
polySBMA in 0.30 M NaCl(aq) 1:1
Solvents tested
Ethanol
Acetone
NaCl(aq)
Results
When using ethanol or acetone, polySBMA would not dissolve and instead dehydrate and form into a hard polymer ball.
Optimal solvent conditions
NaCl(aq) proves to dissolve polySBMA. At concentration below 0.25 M NaCl, beading occurs at the intersections; above 0.25M, fibers are uniform.
✓ Spraying Pressure
10 psi
20 psi
30 psi
When pressure reaches 30 psi, fibers are produced.
✓ Spraying nozzle diameter
Set at large diameter, or approximately 5 rotations wide.
Set at small diameter, or approximately 2 rotations wide.
✓ Varying photo-initiator concentration
The concentration of photo-initiator is calculated on a basis of 10 mL of a 1:1 polySBMA to solvent solution with 200 µL of TEGDMA.
✓ Water solubility
No photo-initiator, cross-linker, or UV exposure
0.022 M photo-initiator 4 minute UV exposure
0.009 M photo-initiator 8 minute UV exposure
Conclusions
- Increasing KCl concentration decreases M.W. and produces uniform fibers
- Increasing NaCl concentration allows for spraying and produces uniform fibers
- Optimal spraying occurs at 30 psi and "2-rotation" nozzle diameter
- Optimal photo-initiator concentration is 0.009 M
- Photo-polymerization reduces water solubility
Future Work
1. Characterize the base case microfiber dimensions
2. Demonstrate nonfouling properties
3. Quantify polySBMA M.W. by gel permeation chromatography
4. Characterize the release of two pseudo-drug species
Acknowledgements
- National Grand Challenge Scholars Program
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University of Idaho
Office of Undergraduate Research

University of Idaho

Effects of pre-transport administration of Meloxicam on indicators of protein metabolism in transported 4-day old Jersey calves

Myers C. A., Z. Carlson, G. Murdoch, and G. E. Chibisa

University of Idaho, Moscow, ID

Introduction

- Currently, 1 in 10 heifers and most bull-calves are transported to calf-rearing facilities within the first 48 h of birth in the U.S.
- Transport at this vulnerable stage causes stress-related changes in protein metabolism that could restrict growth, since an increase in blood cortisol was shown (Gore et al., 1993; Paddon-Jones et al., 2006) to cause muscle wasting in humans by increasing the rate of protein breakdown relative to synthesis.
- However, there is no information on the impact of transport-related stress on protein metabolism in calves, and the strategies that could potentially be used to mitigate the negative outcomes.
- Our objective was to investigate the effects of transport stress and pre-transport administration of an analgesic in calves (< 1 week old) on blood metabolites, and the gene expression profiles for markers of protein breakdown and synthesis in muscle.

Methods

- A total of 20 calves (age ±SD; 4 ± 0.5 day) were randomly administered either a placebo (CON; n = 10) or meloxicam (MEL; n = 10) orally (1 mg/kg) right before a 8-h road trip.
- Blood samples were collected before departure (0 h), on arrival (8 h) and 96 h post-arrival and analyzed for cortisol and haptoglobin (0 & 8 h samples), and 3-methylhistidine (3-MH), plasma urea-N (PUN) and amino acids (AA; 96 h samples).
- After collection of the last blood sample (96 h), calves were slaughtered by captive bolt and exsanguination.
- Skeletal muscle tissue samples were collected and used to determine transcript abundance of 3 markers of protein synthesis and breakdown using qPCR.

Results

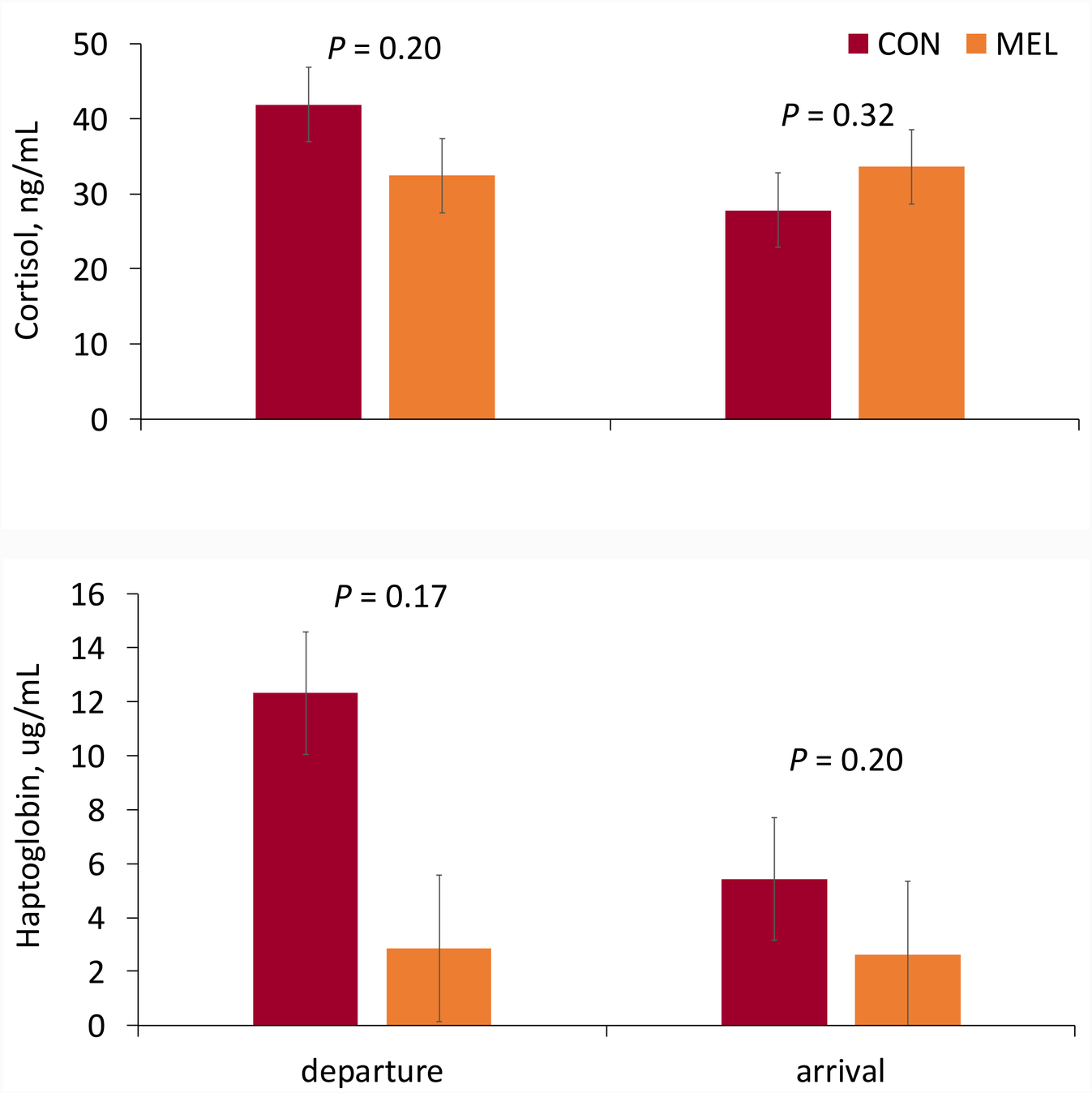

Figure 1. Blood cortisol and haptoglobin concentration at departure and arrival in calves administered either a placebo (CON) or meloxicam (MEL) prior to road transport (8 h trip).

Table 1. Plasma AA, 3-methylhistidine and urea-N concentration 96-h post-arrival in calves administered either a placebo (CON) or meloxicam (MEL) prior to road transport (8 h trip).

	Treatment			
Variable	CON	MEL	SEM	*P*-Value
Alanine	133	119	11.7	0.41
Arginine	2.96	4.78	0.89	0.17
Asparagine	31.8	31.9	1.70	0.99
Aspartic acid	15.7	14.7	0.83	0.41
Citrulline	7.87	5.47	0.87	0.07
Glutamic acid	34. 4	31.3	2.95	0.47
Glutamine	16.6	14.6	0.99	0.18
Glycine	32. 8	33.8	2.30	0.75
Histidine	31.6	29.0	2.01	0.36
Isoleucine	19.2	15.2	1.25	0.04
Leucine	33.2	29.8	1.77	0.19
Lysine	11.3	10.6	0.68	0.48
Methionine	5.50	5.43	0.261	0.84
Phenylalanine	31.0	28.4	2.47	0.46
Proline	11.2	9.6	0.81	0.19
Serine	9.218	8.632	0.63	0.52
Threonine	10.2	9.3	0.49	0.21
Tryptophan	46.5	41.2	3.554	0.30
Tyrosine	38.9	34.7	3.044	0.33
Valine	7.91	6.73	0.526	0.13
3-methylhistidine	0.380	0.368	0.036	0.82
Urea-N	12.3	11.5	0.799	0.46

Effects of pre-transport administration of Meloxicam on indicators of protein metabolism in transported 4-day old Jersey calves

Myers C. A., Z. Carlson, G. Murdoch, and G. E. Chibisa

University of Idaho, Moscow, ID

Results (cont.)

Table 2. Transcript abundance of genes related to mammalian target of rapamycin (mTOR) and ubiquitin-proteasome system (UPS) in calves administered either a placebo (CON) or meloxicam (MEL) prior to road transport (8 h trip).

	Treatment			
Variable[1]	CON	MEL	SEM	*P*-Value
mTOR (protein synthesis)[2]				
mTOR	-4.17	-4.15	0.054	0.848
S6K1	-3.96	-4.02	0.039	0.319
4E-BP1	-4.33	-4.33	0.041	0.100
EIFK3	-3.44	-3.44	0.036	0.932
UPS (protein breakdown)[3]				
UBA	-4.70	-4.70	0.058	0.871
UBE2G1	-3.50	-3.44	0.055	0.421
UBE2G2	-5.93	-5.91	0.060	0.823
Atrogin-1	-5.73	-5.75	0.057	0.832
TRIM-63	-3.34	-3.31	0.056	0.672

[1]copies/copy 18S

[2]S6k1 = ribosomal protein S6 kinase, 4E-BP1 = eukaryotic translation initiation factor 4E binding protein, EIFK3 = eukaryotic translation initiation factor 3

[3]UBA = ubiquitin-like modifier activating enzyme, UBE2G1 and UBE2G2 = ubiquitin conjugating enzymes, TRIM63 = E3 ubiquitin-protein ligase

Table 3. Production performance in calves administered either a placebo (CON) or meloxicam (MEL) prior to road transport (8 h trip).

	Treatment			
Variable	CON	MEL	SEM	*P*-Value
Transportation shrink, kg	1.68	1.75	0.374	0.896
ADG for 4 d, kg/d	1.95	1.983	0.096	0.814
Milk replacer intake, kg/d	1.067	1.129	0.021	0.05
Feed efficiency	1.841	1.761	0.102	0.584

Summary

- There was no treatment effect on blood cortisol and haptoglobin concentrations, whereas isoleucine was higher and citrulline concentration tended to be higher for MEL than CON calves.
- Although milk replacer intake tended to be higher for MEL compared to CON calves, there was no treatment effect on transportation shrink, ADG and feed efficiency
- Pre-transport administration of MEL had no effect on blood cortisol concentration, and this possibly accounts for the lack of a treatment effect on most measures of protein metabolism including blood urea-N, 3-MH, and mRNA abundance for components of the mTOR or UPS pathways.

References

1) Gore et al., 1993. Ann. Surg. 218:679-684.
2) Paddon-Jones et al. J. Clin. Endocrinol. Metab. 91:4836-4841.doi:10.1210/jc.2006-0651

Why your gut may be working against you: gut derived molecules cause dysmotility and neuropathy in high fat fed mice

Jessica Nicholson[1], Sydney Kuther[1], Yvonne Nyavor[1], Heino Heyman[2] , Thomas Metz[2], Onesmo Balemba[1]

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INTRODUCTION

Type 2 Diabetes (T2D) is the seventh leading cause of death in the United States. Along with this disease comes several neurological effects like enteric neuropathy and even blindness. Previous studies using mice fed a high fat (HF) diet suggest that symptoms of gastrointestinal (GI) dysmotility and neuropathy develop before diabetes. In addition, ileocecal supernatants from HF mice cause GI muscle contractions to slow down, and also causes a decrease in inhibitory myenteric neurons[1]. *However, substances from GI content that disrupt bowel motility and damage GI neurons are not known*.

HYPOTHESIS

Ileocecal supernatants from HF diet mice separated into fractions will cause gastrointestinal dysmotility and neuropathy.

GOAL

Identify gut derived molecules that may cause diabetic dysmotility and/or neuropathy.

MATERIALS/METHODS

- Ileocecal supernatants from mice were fractionated using high performance liquid chromatography (HPLC)
- Intestinal tissues were dissected from C57BL/6J mice down to the longitudinal muscle myenteric plexus, cultured with ileocecal supernatant fractions for 48 hours, and fixed with 4% Paraformaldehyde
- Contractions were counted at 0, 24, and 48 hours
- Tissues were stained for neuronal nitric oxide synthase (nNOS) and anti-neuronal nuclear autoantibody-1 (ANNA-1) using immunohistochemistry
- Samples were imaged using a Nikon Spinning Disk microscope and analyzed with Nikon's NIS Elements software

HF diet causes production of substances that disrupt intestinal muscle contractions

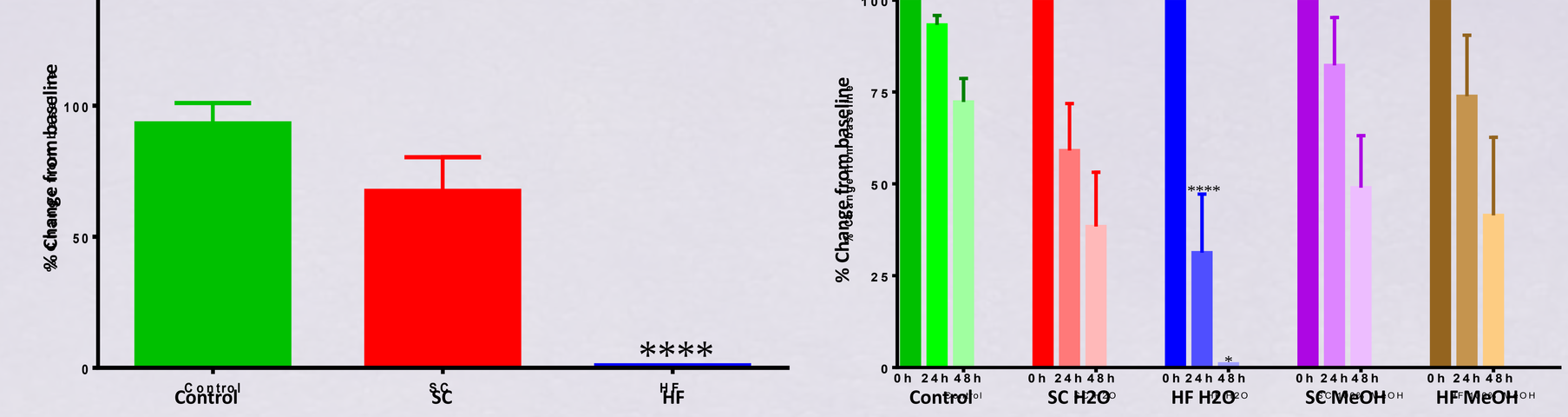
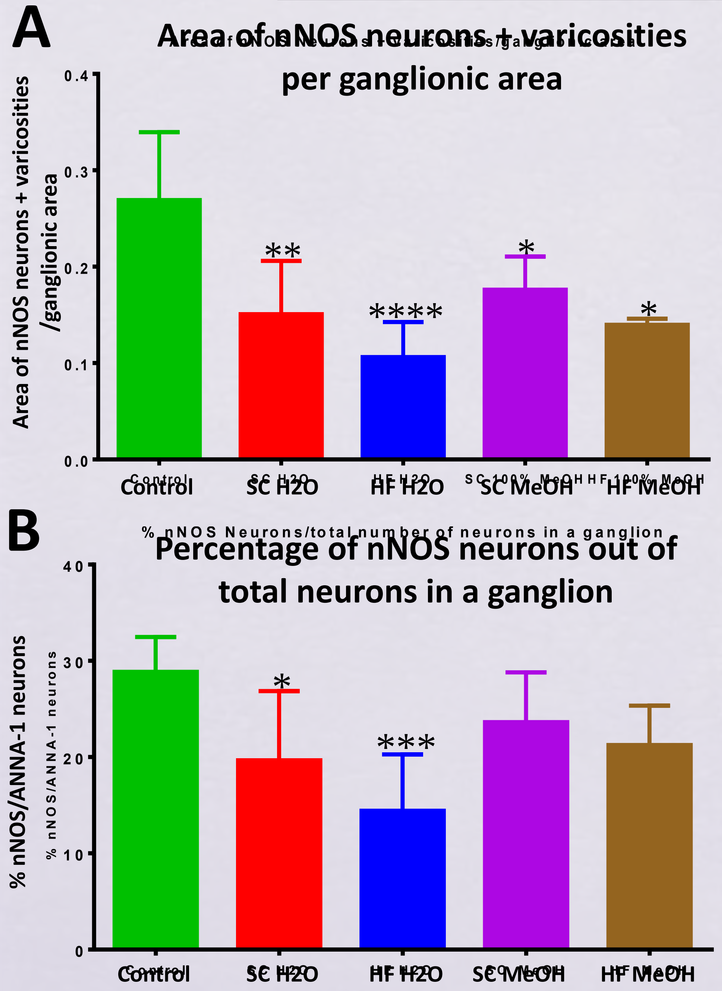


Figure 1. A) Preliminary data showing a significant reduction in smooth muscle contractions of samples exposed to HF mice ileocecal supernatant. B) HF water fractions decreased smooth muscle contraction suggesting they contain active molecules. *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001, ****p ≤ 0.0001; n= 2-9

Fractions from ileocecal supernatant cause reduction in nNOS neurons



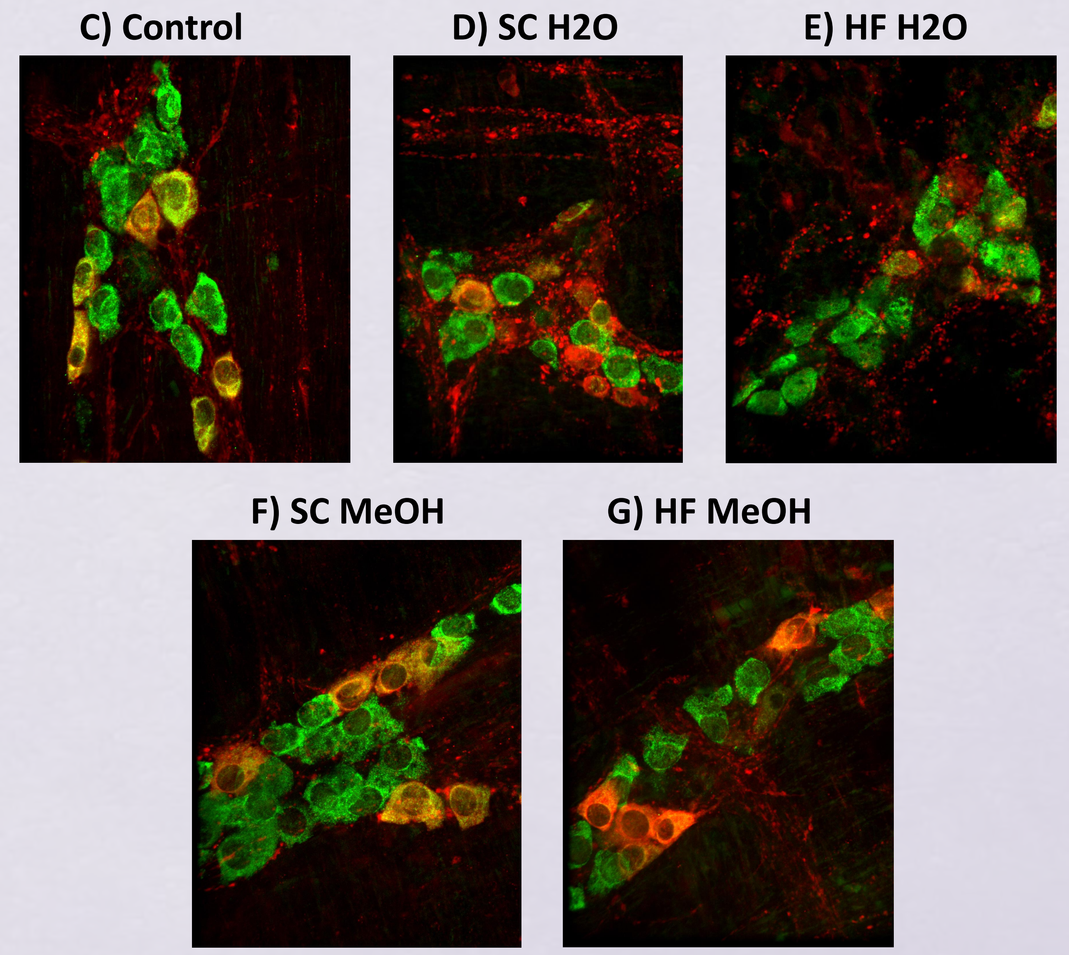


Figure 2. A-B) Summary data showing a significant decrease in nNOS neurons (inhibitory motor neurons) and varicosities in tissues treated with ileocecal fractions from both SC and HF mice (A) and a decline of nNOS neurons in tissues treated with the HF water fractions (B). C) Representative image of nNOS (in red) and ANNA-1 (in green) stained neurons and varicosities from an untreated cultured sample. D) Representative image of sample treated with SC H2O fraction. E) Representative image of sample treated with HF H2O Fraction, showing poor condition of ANNA-1 neurons and no nNOS neurons. F) Representative image of sample treated with SC MeOH fraction. G) Representative image of sample treated with HF MeOH fraction. n= 3-9

DISCUSSION

High fat ingestion causes enteric neuropathy in mice by eliciting oxidative stress and inflammation in inhibitory motor (nNOS) neurons. This is though to be due to dietary factors – mainly palmitate and bacterial lipopolysaccharide[2]. What causes dysmotility is unknown. Our results suggest that HF water fractions contain molecules that block muscle contractions and damage inhibitory motor neurons.

CONCLUSION

These results suggest that molecules present in supernatant of HF diet mice ileocecal content causes dysmotility and neuropathy in mice. Further sub-fractionation and analysis of chemical composition could help broaden knowledge about causes of dysmotility and neuropathy in obese and diabetic patients.

FUTURE WORK

HF water fractions causing dysmotilty and neuropathy will be further fractionated down to sub-fractions so that the molecules causing dysmotility and neuropathy can be identified.

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2. Cani, P. D., Amar, J., Iglesias, M. A., Poggi, M., Knauf, C., Bastelica, D., . . . Burcelin, R. (2007, July 01). Metabolic Endotoxemia Initiates Obesity and Insulin Resistance. Retrieved from http://diabetes.diabetesjournals.org/content/56/7/1761.short

ACKNOWLEDGEMENTS

This project was supported by the Office of Undergraduate Research through a Research Fellowship made possible by a 2017-2018 grant from the Higher Education Research Council/Idaho State Board of Education. I would like to also thank Ann Norton and Michael Camerino for help with imaging and analysis!

Antibody Escape Mutations in Respiratory Syncytial Virus

Frankie Scholz, Sierra Beach, Ashley DeAguero, Craig Miller, Tanya Miura

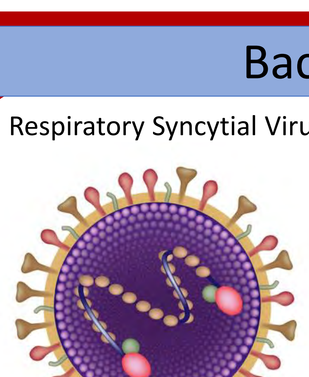
Department of Biological Sciences, University of Idaho, Moscow, ID

Abstract:

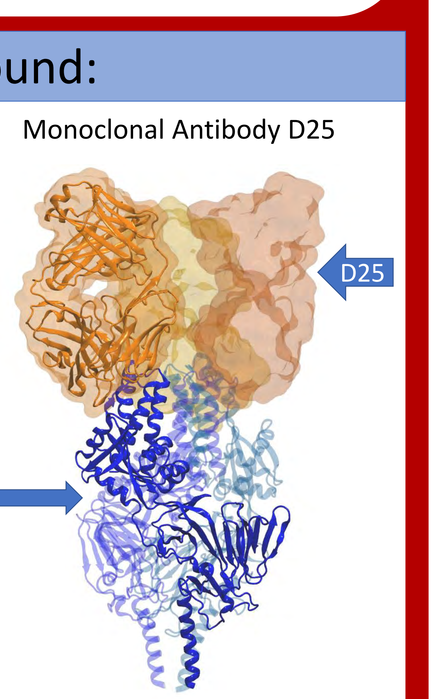
Respiratory Syncytial Virus (RSV) is a small intracellular pathogen that infects people of all ages. RSV is responsible for many deaths each year and currently, there is no licensed vaccine. In an alternate form of therapy, monoclonal antibodies can be used to treat infection, however, the monoclonal antibody, Palivizumab, is only administered to high risk infants. In this study, we are investigating the ability of RSV to mutate under stress of a human monoclonal antibody, D25. Under stress, RSV is pressured to evolve resistance against antibodies, known as antibody escape mutations. We introduced RSV to rounds of selection in the presence of D25 and allowed time for mutations to arise. After ten rounds of selection in HEp-2 cells, viral mutants required significantly more antibody for neutralization. The mutants were sequenced for specific amino acid changes and compared to the modeled predictions. These results will help us better understand how RSV evolves to escape neutralization.

Background:

Respiratory Syncytial Virus



Monoclonal Antibody D25



- RSV has a single-stranded, negative sense RNA genome
- It's a significant pathogen among young children, the elderly, and the immunocompromised
- The Fusion (F) protein fuses the viral membrane with the host cell membrane for viral entry into host cells
- F protein is the main target of neutralizing antibodies
- F is also the target for vaccine strategies that are currently in development and the target of monoclonal antibody therapy by Palivizumab

- D25 is a human monoclonal antibody that has potent neutralizing activity against RSV
- D25 is in clinical trials as an RSV therapeutic
- D25 binds to the pre-fusion form of F and inhibits fusion and viral entry
- It is important to understand how RSV can evolve to avoid neutralization by D25

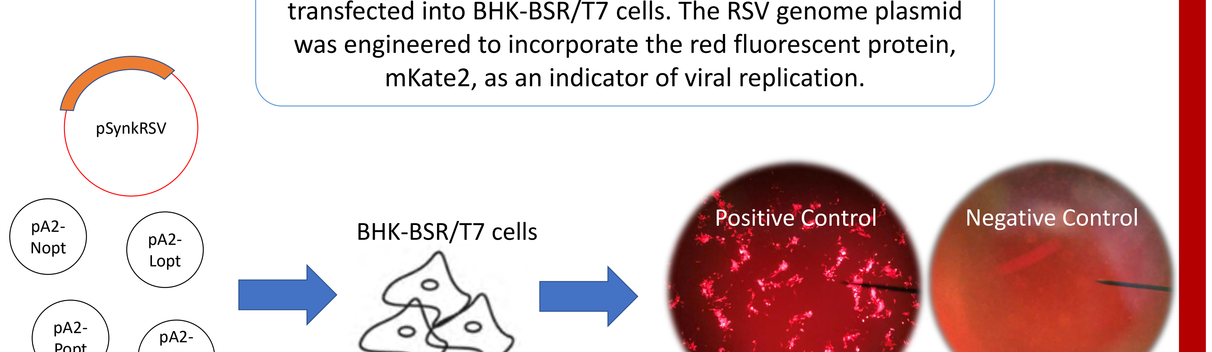
Hypothesis:

- We hypothesize that RSV will mutate under stress of a sub-inhibitory dose of antibodies (D25) resulting in escape from neutralization.
- We also predict that molecular modeling done by our collaborators, Drs. Marty Ytreberg and Jagdish Patel, will be able to accurately predict these mutations.

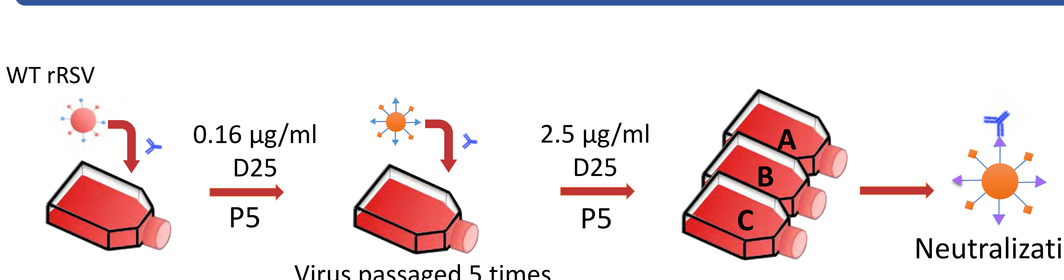
Methods:

Generating RSV that Expresses a Red Fluorescent Protein

A plasmid with the RSV genome and helper plasmids were transfected into BHK-BSR/T7 cells. The RSV genome plasmid was engineered to incorporate the red fluorescent protein, mKate2, as an indicator of viral replication.

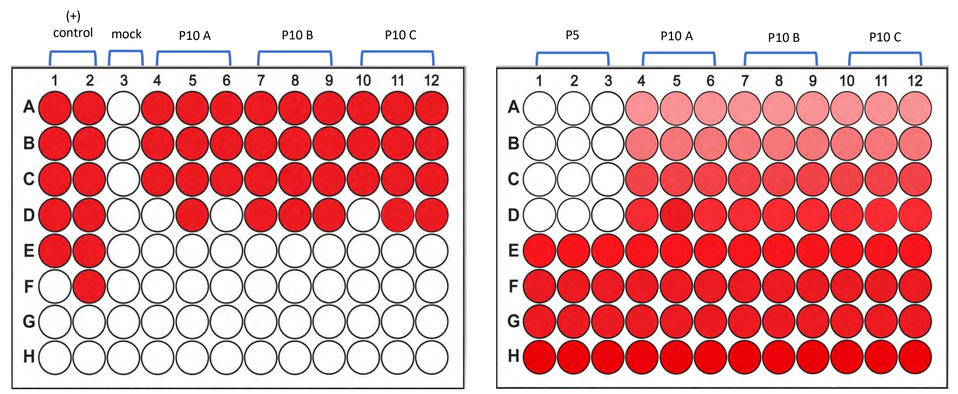


Experimental Evolution of RSV to Select Antibody Escape Mutations

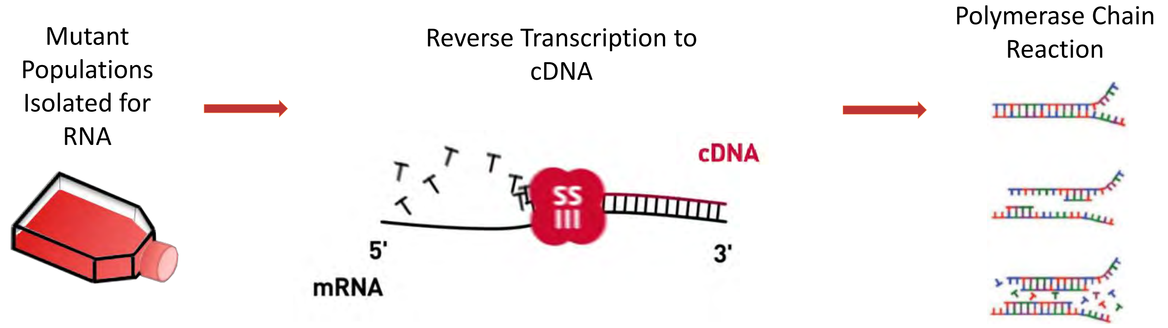


Quantifying RSV by $TCID_{50}$ Assay

Determining Neutralizing Concentration of Antibody

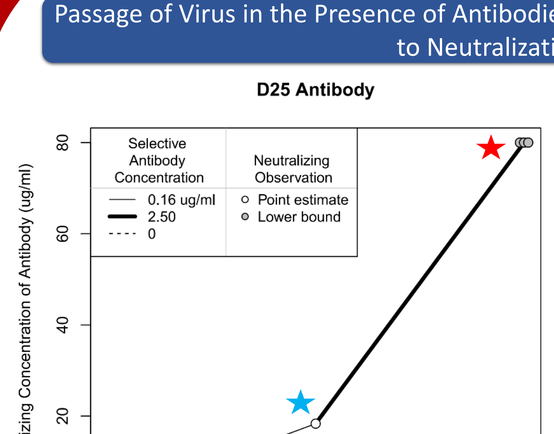


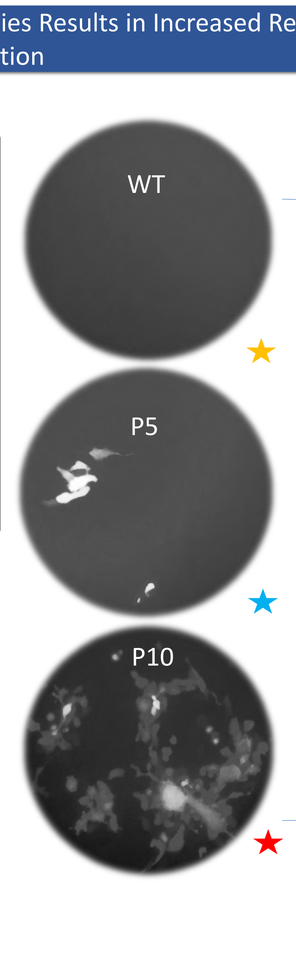
Isolating Mutant RNA to be Reverse Transcribed to DNA for Sequencing



Results:

Passage of Virus in the Presence of Antibodies Results in Increased Resistance to Neutralization

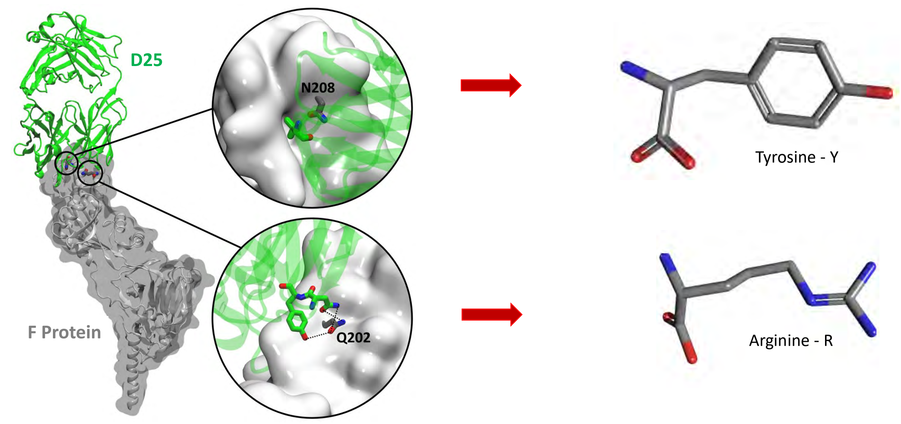




Passaged Viruses Acquired Two Point Mutations Sequentially

★ Wild-type F Amino Acid Sequence	QLLPIVN
★ P5-low [Ab]	QLLPIVY
★ P5-low [Ab]/P5-no [Ab]	QLLPIVY
★ P5-low [Ab]/P5-high [Ab] A	RLLPIVY
★ P5-low [Ab]/P5-high [Ab] B	RLLPIVY
★ P5-low [Ab]/P5-high [Ab] C	RLLPIVY

The Mutations are Predicted to Disrupt the Interaction Between D25 and F



Conclusion and Future Directions:

- After ten rounds of selection in HEp-2 cells, viral mutants required significantly more antibody for neutralization.
- The F protein has mutated that allows it to escape neutralization and the amino acid residues that mutated are predicted to disrupt the interaction between D25 and F.
- Later, we will engineer the predicted D25 mutants into the infectious clone to validate their resistance to D25 and compare their fitness to the wild-type virus.

Acknowledgements and References:

- *Research reported in this poster was supported by the National Science Foundation EPSCoR Research Infrastructure Improvement Program: Track-2, award number OIA-1736253.*
- We gratefully acknowledge Dr. and Mrs. Hill for their support with the Hill Fellowship Grant and the Office of Undergraduate Research for the SURF Fellowship and OUR Grant.
- An additional thank you to Bhim Thapa and Andres Gonzalez for their support and advice as well as Dr. Marty Ytreberg and Dr. Jagdish Patel for the modeling.

- 1. Meng J, Stobart CC, Hotard AL, Moore ML (2014) An Overview of Respiratory Syncytial Virus. PLoS Pathog 10(4): e1004016. doi:10.1371/journal.ppat1004016

Non-Thermal Liquid Plasma Treatment for Removal of Antibiotics in Wastewater

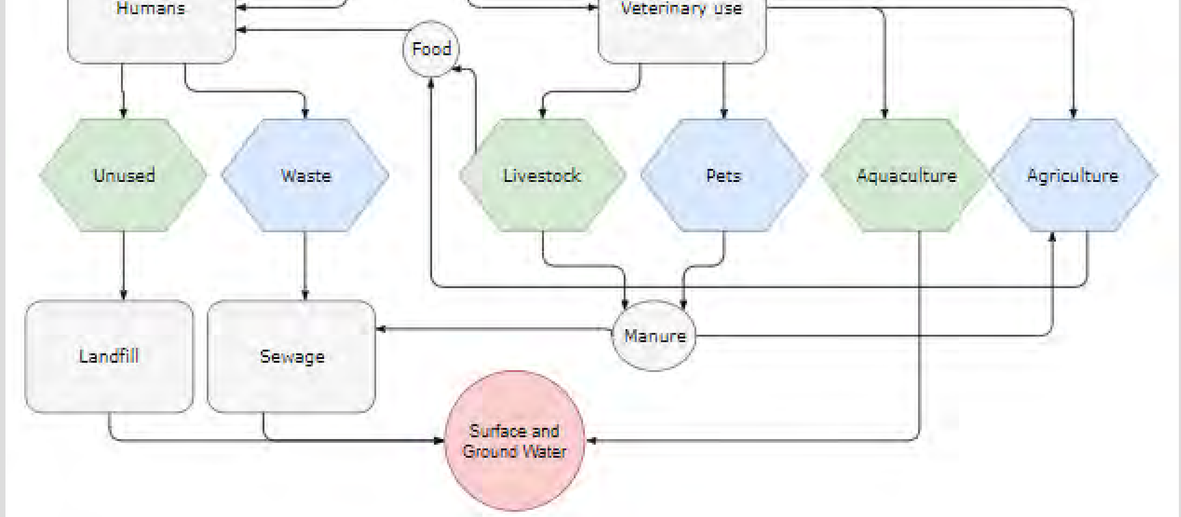
McKenzie Walquist and Dr. Sarah Wu, Department of Biological Engineering

University of Idaho College of Engineering

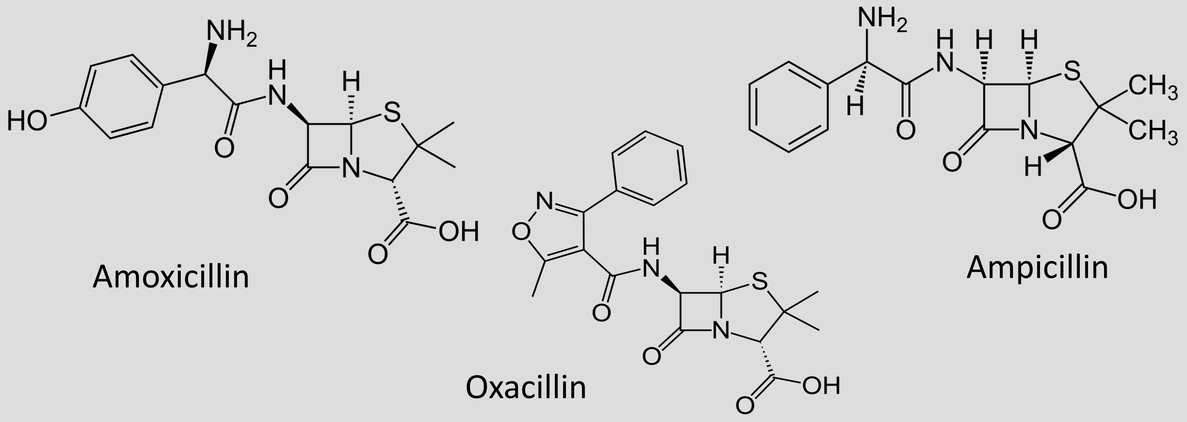
This project was supported by the University of Idaho through the State Board of Education

Traditional wastewater treatment processes are not able to degrade pharmaceuticals which find their way into the water system. As a result, many bacterial strains have become antibiotic resistant, which is a significant medical concern. One solution currently being explored to prevent these emerging contaminants from being released into the environment is advanced oxidation processes (AOPs), including non-thermal liquid plasma (NTLP) treatment. This process produces high energy mobile electrons and oxidizing radicals which degrade large organic molecules.

Sources and cycles of antibiotics



A circulating treatment of tap water to simulate a wastewater stream, was used to remove three types of beta-lactam penicillins (ampicillin, oxacillin sodium salt, and amoxicillin trihydrate).



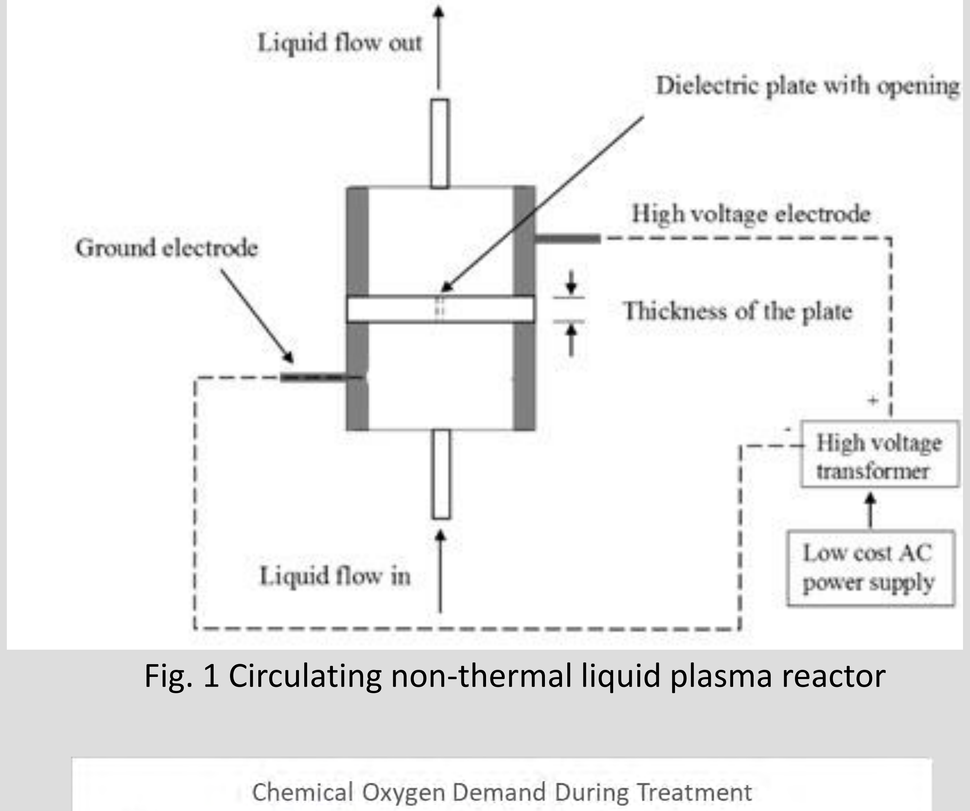
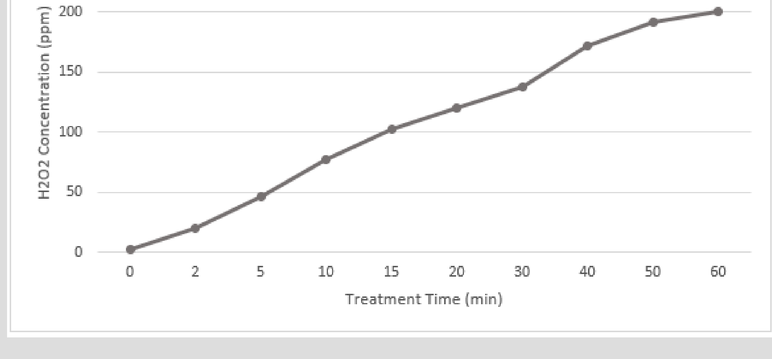


Fig. 1 Circulating non-thermal liquid plasma reactor

Oxidation

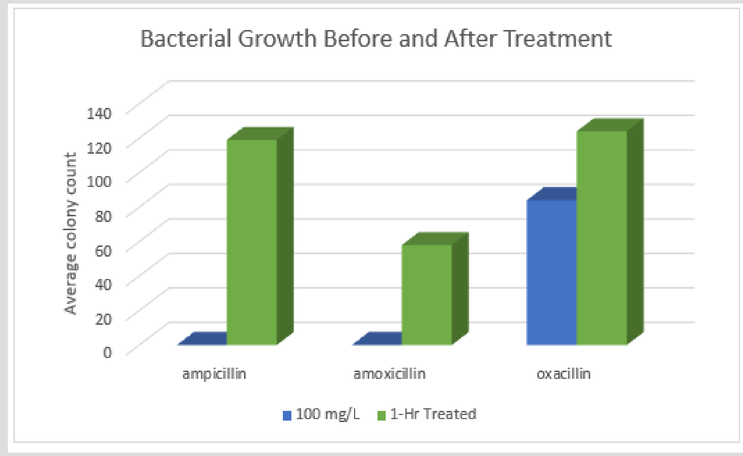
The high voltage between the NTLP reactor electrodes physically breaks the large molecules, and also creates hydrogen peroxide, ozone, and hydroxyl ions. These radicals assist in further oxidizing organic molecules.



H_2O_2 increases with treatment time. The pH of the solution also increases, suggesting the production of –OH radicals. The decrease in COD suggests the molecules are degraded and oxidized.

Toxicity

In each replicated experiment, using E. coli K12, the bacteria did not grow when plated with either Ampicillin or Amoxicillin. However, when plated with the 1-hour treated solutions, the bacteria were able to grow to the similar colony counts as treated tap water without antibiotics. This suggests the antibiotics were degraded to a point that could no longer affect bacteria at this concentration. This strain of bacteria was not inhibited by the Oxacillin, but the treated solution was shown to also be non toxic.



What's Next?

- ❑ LC/MS analysis to identify intermediates and final degradation products
- ❑ Reactor optimization and commercialization

FY17 HERC Undergraduate Research: Lewis-Clark State College								
Student (s)	**Student Major**	**Project Summary**	**Project Amount**	**Stipend**	**Supplies**	**Travel**	**Faculty PI**	**Dissemination**
Hannah Uhlenkott, Jessie	Exercise Science	The effects of plyometric training on knee flexion angles	1,081	300	732	49	Jessica Savage	Poster- American College of Sports Medicine
Delaney Jones	Computer Science/Bio	Merging in Mouse Eyes- Investigating Retinal Neurons	2,000	2,000			Seth Long	Poster- ICUR and Idah
Kory Parker	Biology	Morphological and growth characterisitics of *Candida auris* and potential antifungal compounds against	5,025	4,200	825		Jacob Hornby	Presentation- LCSC research syposium; Poster- ICUR
Sarah Eberle	Biology	The effect of spontaneous mutations on neural function	2,600	2,100	500		Leigh Latta	Poster- ICUR and Idaho INBRE
Brian Grimm	Chemistry	Analysis of Volatile Organic and Sulfur Compunds in the air	5,700	2,700	2,800	200	Nancy Johnston	Poster- ICUR
Rayanna Grove	Biology	Relative Effects of genetics to snake head morphology	3,594	2,160	382	1,052	Mike Edgehouse	Ongoing- summary report; ICUR summer 2019
Presentation Materials								
Totals			**20,000**	**13,460**	**5,239**	**1,301**		

Other outcomes
Professional school admittance: Jessie (OT), Hannah and Kendall (PT)
Current student- offer to work on data set from NASA consultant firm
University of Nebraska. Summer REU at University of Nebraska
Current student- interviewing at Dental Schools
MS in Environmental Engineering at WSU
Current student

Final Report for HERC Funding for the 2018 Idaho Conference on Undergraduate Research (ICUR)
Submitted by Donna Llewellyn, Executive Director of the Boise State Institute for STEM and Diversity Initiatives

ICUR 2018 was held on July 25 and 26, 2018 at Boise State University. The total attendance was 296 (not counting some who only came to see the poster sessions), from 38 different institutions/organizations. This included 202 students with 164 poster presentations, and 94 faculty, industry, and governmental representatives. We are aware that this is a decline from the 2017 conference and we are looking at the data to try to understand where the reductions came from and to address these with our campus partners. We have also added a partner at College of Southern Idaho in order to include their students (and faculty) in the future.

There were two full days of workshops and presentations – see the following pages for the program schedule. More details are also available at https://academics.boisestate.edu/icur/
A pdf version of the printed program that was handed out at the event is available upon request.

A survey was been sent out to all of the attendees. The likert scale responses and an overview of the open-ended responses are attached. We intend to use these results to improve the conference next year.

The funding from HERC went to the following categories of expenditures:

Item	Amount
Catering	$9643.31
Program Design and Printing	$3016.60
Plenary Speaker Hotel	$258.00
Facilities and Events	$138.00
Materials and Supplies	$233.52
Admin Support	$1710.47
TOTAL	**$15,000**

Other support for the conference came from a number of grant programs at Boise State University, the Institute for STEM and Diversity Initiatives, the University of Idaho, and Idaho State University.

ICUR 2018 **PROGRAM**

ALL SESSIONS ARE IN THE STUDENT UNION BUILDING UNLESS OTHERWISE NOTED

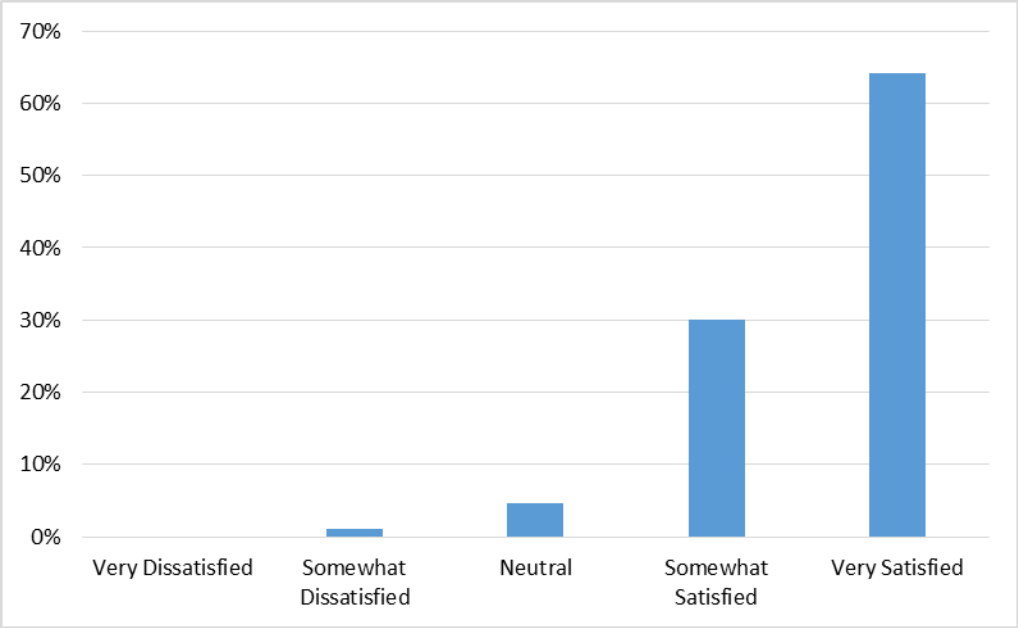
TIMES	WEDNESDAY, JULY 25
8:00 AM	**REGISTRATION:** Simplot Ballroom Lobby **POSTER SET-UP:** Simplot Ballroom/Snacks
9:00 – 9:25 AM	**OPENING CEREMONY/CONTINENTAL BREAKFAST** **David Hill**, Idaho State Board of Education **Location:** Jordan Ballroom D
9:25 – 10:15 AM	**PLENARY SPEAKER:** **Noël Bakhtian**, Director, CAES **TITLE:** **GLOBAL GRAND CHALLENGES: THE ENERGY-WATER NEXUS** **Location:** Jordan D Ballroom
10:15 – 10:30 AM	**BREAK**
10:30 11:30 AM	**NSF GRFP AND OTHER SCHOLARSHIPS** **Facilitator:** **Facilitator: Liljana Babinkostova**, Boise State University **Speakers:** **Student Panel** **Location:** Bishop Barnwell **PROFESSIONAL NETWORKING: HOW TO DO IT** **Panelists:** **Adrean Cavener**, Dutch Bros **Jaime Lima**, New York Life Insurance Co. **Duree Westover**, Experis **Location:** Lookout Room
11:45 AM– 1:45 PM	**POSTER PRESENTATIONS AND BUFFET LUNCH** **LOCATION:** Simplot Ballroom
1:45 – 2:00 PM	**BREAK**
2:00 – 3:30 PM	**HOW to be MENTORED** **Facilitator:** **Paul Rowley**, University of Idaho **Location:** Bishop Barnwell **LIGHTNING TALKS** **Speakers:** **Brittany Brand**, Boise State University **Caroline Earley**, Boise State University **Elizabeth Gutting**, Boise State University **Ayokunle Hodonu**, Northwest Nazarene University **Eric Jankowski**, Boise State University **Peter Müllner**, Boise State University **Heidi Reeder**, Boise State University **Mac Test**, Boise State University **Location:** Lookout Room
3:30 – 3:45 PM	**BREAK**
3:45 – 5:15 PM	**GRADUATE PANEL: GETTING INTO (AND THROUGH) GRADUATE SCHOOL** **Moderator:** **Sarah Ritter**, Boise State University **Speakers:** **Faculty Panel** **Location:** Bishop Barnwell **DEVELOPING AN ONLINE PERSONA** **Speaker:** **Laura Chiuppi**, Boise State University **Location:** Lookout Room
5:30 PM	**DINNER ON YOUR OWN – CHECK OUT ALIVE AFTER FIVE ON THE GROVE (https://www.facebook.com/aliveafterfiveboise/)**
	THURSDAY, JULY 26
8:00 AM	**REGISTRATION:** Simplot Ballroom Lobby **POSTER SET-UP:** Simplot Ballroom/Snacks
9:00 – 10:00 AM	**CONTINENTAL BREAKFAST** **Plenary Speaker:** **Celia Gould**, Director, Idaho Department of Agriculture **TITLE:** **A LOOK INTO STATE GOVERNMENT, AGRICULTURE AND RESEARCH NEEDS** **Location:** Jordan Ballroom D
10:00 – 10:15 AM	**BREAK**
10:15 – 11:30 AM	**RESEARCH TALKS** **Speakers:** **Dr. John Dudgeon**, Idaho State University **Dr. Joel Green**, Space Telescope Science Institute **Dr. Julie Straight**, Northwest Nazarene University **Location:** Bishop Barnwell **INDUSTRY PANEL: HOW TO FIND AND SUCCEED IN YOUR FIRST JOB** **Panelists:** **Michelle Rauer**, Chobani **Michelle Ross**, St. Luke's Health System **Location:** Lookout Room
11:30 – 11:45 AM	**BREAK**
11:45 AM – 1:45 PM	**POSTER PRESENTATIONS AND BUFFET LUNCH** **LOCATION:** Simplot Ballroom
12:45 – 1:45 PM	***IDAHO DIVERSITY NETWORK MEETING** **Facilitator:** Sarah Penney, Idaho NSF EPSCoR **Location:** *By invitataion only
1:45 – 2:00 PM	**BREAK**
2:00 – 3:15 PM	**GRADUATE SCHOOL — THE REAL STORY** **Moderator:** **Gregory Martinez**, Boise State University **Speakers** **Student Panel** **Location:** Bishop Barnwell **HOW TO TRANSLATE RESEARCH EXPERIENCE INTO JOB SKILLS** **Facilitators:** **Catherine Bates**, Boise State University **Dave Byers**, J.R. Simplot Company **Megan Boatman**, Boise State University **Location:** Lookout Room
3:15 PM	**CLOSING CEREMONY** **Speakers:** **Dr. William Hughes**, Boise State University **TITLE:** **THE MANY HATS OF SCIENCE** **Location:** Jordan Ballroom D
4:00 PM	**PLANNING COMMITTEE BUSINESS MEETING** **Location:** Foote Room

Idaho Conference on Undergraduate Research 2018
Survey Results

RESPONSE RATE: 57.4%

- 296 attendees
- 170 recorded responses
  - 159 completed surveys
  - 11 incomplete responses: All of these answered questions through, "Please select your role."

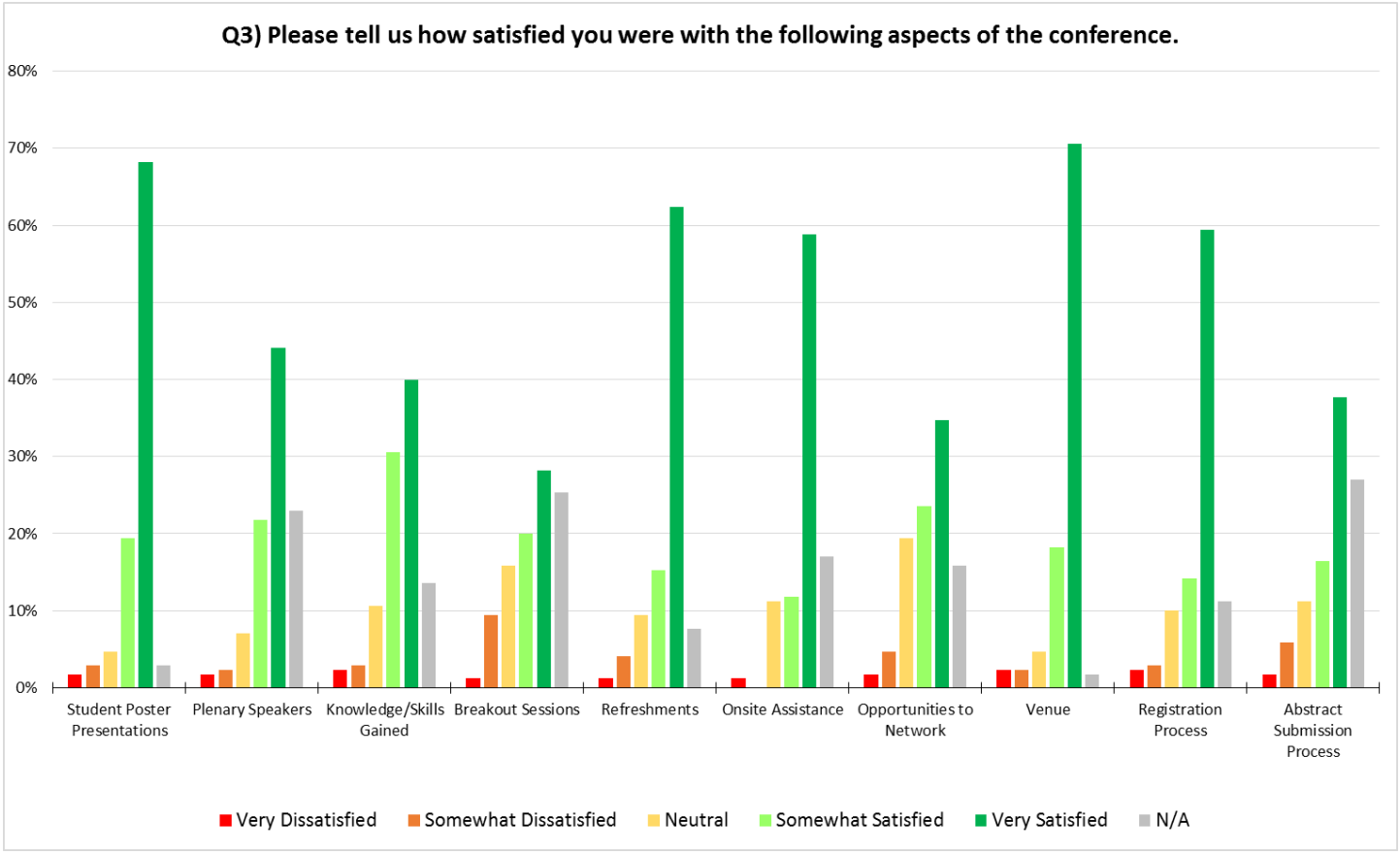
Q2) Please indicate your overall satisfaction with the 2018 Idaho Conference on Undergraduate Research.



Answer	%	Count
Very Dissatisfied	0.0%	0
Somewhat Dissatisfied	1.2%	2
Neutral	4.7%	8
Somewhat Satisfied	30.0%	51
Very Satisfied	64.1%	109
Total	100.0%	170

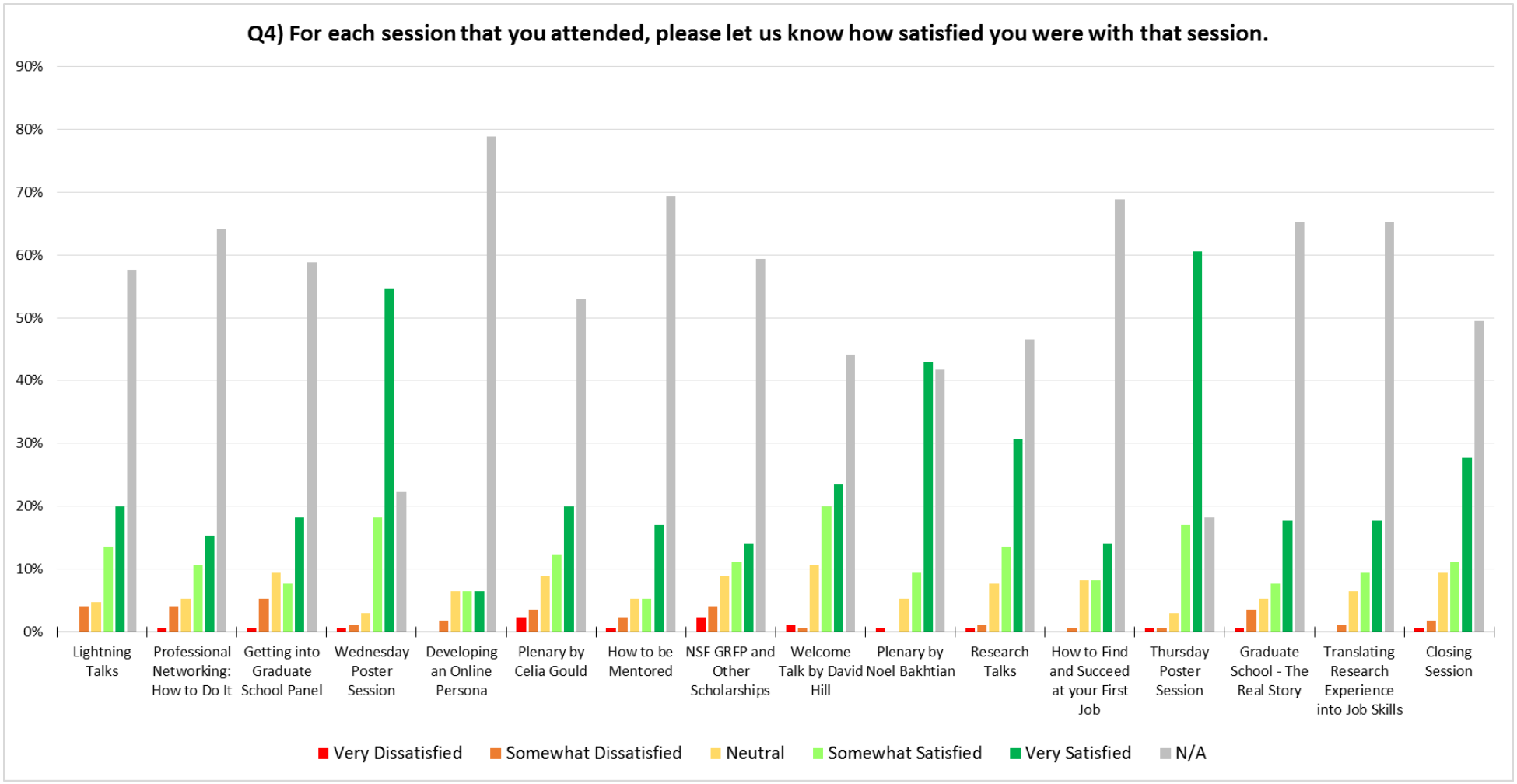
Q3) Please tell us how satisfied you were with the following aspects of the conference.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Aspect	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Student Poster Presentations	2%	3	3%	5	5%	8	19%	33	68%	116	3%	5	100%	170
Plenary Speaker	2%	3	2%	4	7%	12	22%	37	44%	75	23%	39	100%	170
Knowledge/Skills Gained	2%	4	3%	5	11%	18	31%	52	40%	68	14%	23	100%	170
Breakout Sessions	1%	2	9%	16	16%	27	20%	34	28%	48	25%	43	100%	170
Refreshments	1%	2	4%	7	9%	16	15%	26	62%	106	8%	13	100%	170
Onsite Assistance	1%	2	0%	0	11%	19	12%	20	59%	100	17%	29	100%	170
Opportunities to Network	2%	3	5%	8	19%	33	24%	40	35%	59	16%	27	100%	170
Venue	2%	4	2%	4	5%	8	18%	31	71%	120	2%	3	100%	170
Registration Process	2%	4	3%	5	10%	17	14%	24	59%	101	11%	19	100%	170
Abstract Submission Process	2%	3	6%	10	11%	19	16%	28	38%	64	27%	46	100%	170

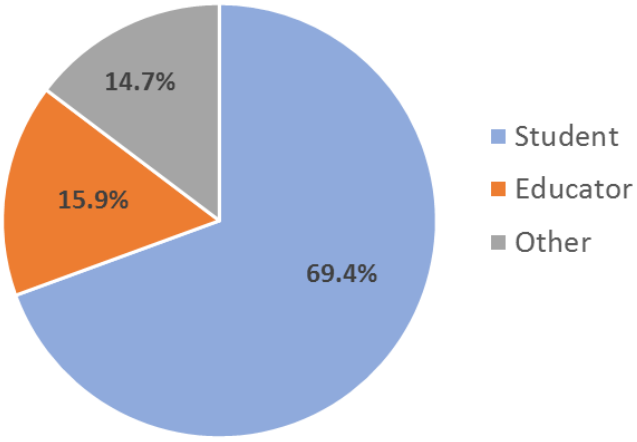


Q4) For each session that you attended, please let us know how satisfied you were with that session.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Session	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Lightning Talks	0%	0	4%	7	5%	8	14%	23	20%	34	58%	98	100%	170
Professional Networking: How to Do It	1%	1	4%	7	5%	9	11%	18	15%	26	64%	109	100%	170
Getting into Graduate School Panel	1%	1	5%	9	9%	16	8%	13	18%	31	59%	100	100%	170
Wednesday Poster Session	1%	1	1%	2	3%	5	18%	31	55%	93	22%	38	100%	170
Developing an Online Persona	0%	0	2%	3	6%	11	6%	11	6%	11	79%	134	100%	170
Plenary by Celia Gould	2%	4	4%	6	9%	15	12%	21	20%	34	53%	90	100%	170
How to be Mentored	1%	1	2%	4	5%	9	5%	9	17%	29	69%	118	100%	170
NSF GRFP and Other Scholarships	2%	4	4%	7	9%	15	11%	19	14%	24	59%	101	100%	170
Welcome Talk by David Hill	1%	2	1%	1	11 %	18	20%	34	24%	40	44%	75	100%	170
Plenary by Noel Bakhtian	1%	1	0%	0	5%	9	9%	16	43%	73	42%	71	100%	170
Research Talks	1%	1	1%	2	8%	13	14%	23	31%	52	46%	79	100%	170
How to Find and Succeed at your First Job	0%	0	1%	1	8%	14	8%	14	14%	24	69%	117	100%	170
Thursday Poster Session	1%	1	1%	1	3%	5	17%	29	61%	103	18%	31	100%	170
Graduate School - The Real Story	1%	1	4%	6	5%	9	8%	13	18%	30	65%	111	100%	170
Translating Research Experience into Job Skills	0%	0	1%	2	6%	11	9%	16	18%	30	65%	111	100%	170
Closing Session	1%	1	2%	3	9%	16	11%	19	28%	47	49%	84	100%	170


Q4) For each session that you attended, please let us know how satisfied you were with that session.
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Lightning Talks
Professional Networking: How to Do It
Getting into Graduate School Panel
Wednesday Poster Session
Developing an Online Persona
Plenary by Celia Gould
How to be Mentored
NSF GRFP and Other Scholarships
Welcome Talk by David Hill
Plenary by Noel Bakhtian
Research Talks
How to Find and Succeed at your First Job
Thursday Poster Session
Graduate School - The Real Story
Translating Research Experience into Job Skills
Closing Session
Very Dissatisfied
Somewhat Dissatisfied
Neutral
Somewhat Satisfied
Very Satisfied
N/A

Q5) Please select your role.

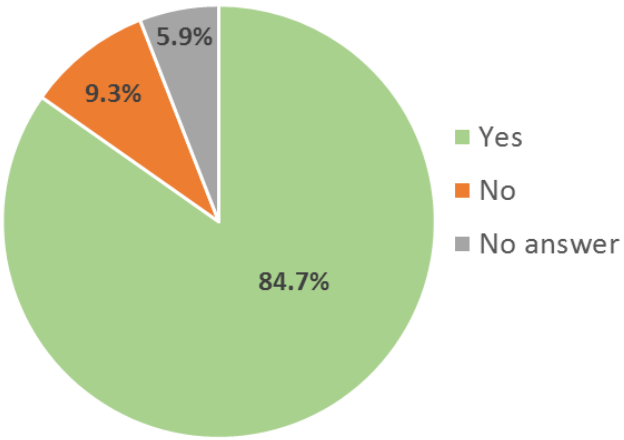


Answer	%	Count
Student	69.4%	118
Educator	15.9%	27
Other	14.7%	25
Total	100.0%	170

Q6) Other roles reported:

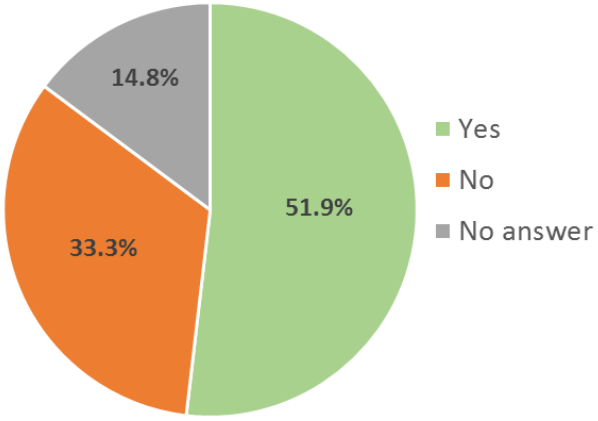
- Administrator
- Conference vistor
- Graduate mentor
- Graduate student
- ICUR committee member
- Invited speaker/panelist
- Mentor
- Parent
- Research funder
- Researcher
- Staff

Q7) Did you present a poster? (This question presented only to the 118 respondents who selected "Student" as their Role.)



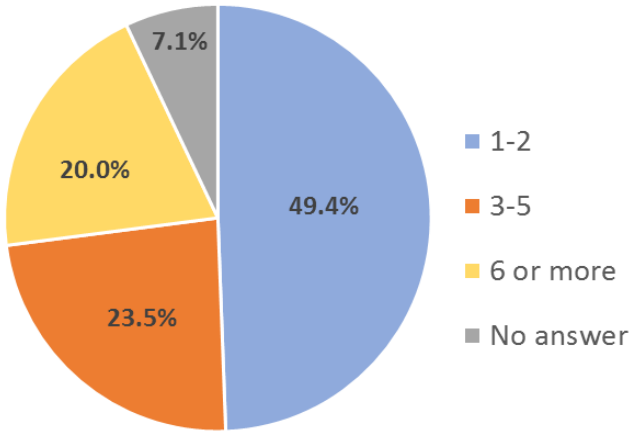
Answer	%	Count
Yes	84.7%	100
No	9.3%	11
No answer	5.9%	7
Total	100.0%	118

Q8) Were you a mentor of a student researcher who presented a poster? (This question presented only to the 27 respondents who selected "Educator" as their Role.)



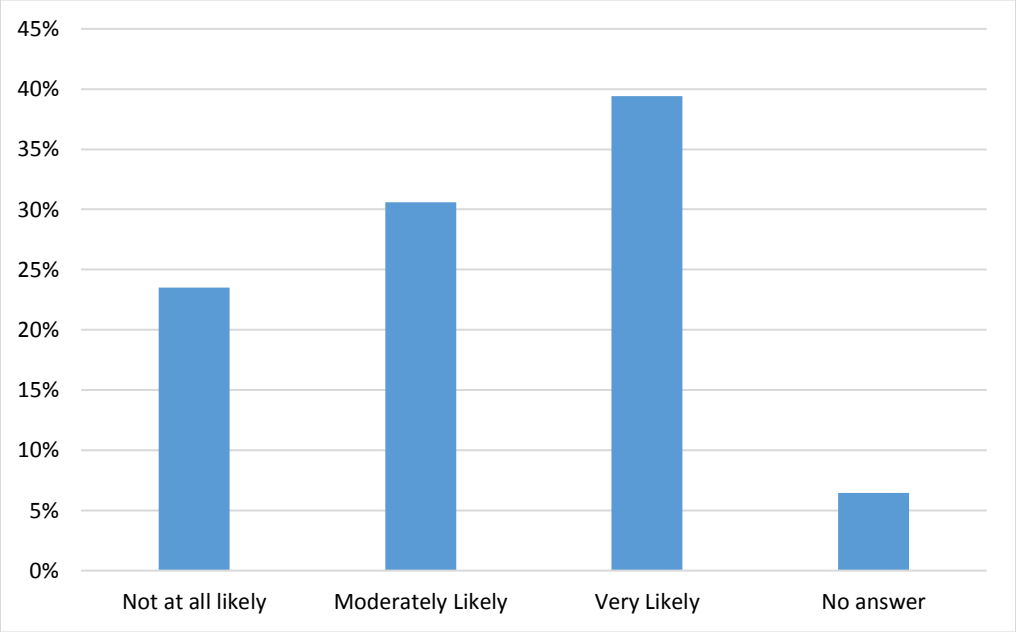
Answer	%	Count
Yes	51.9%	14
No	33.3%	9
No answer	14.8%	4
Total	100.0%	27

Q9) How many conferences (technical and professional conferences) have you attended including this one?



Answer	%	Count
1-2	49.4%	84
3-5	23.5%	40
6 or more	20.0%	34
No answer	7.1%	12
Total	100.0%	170

Q10) How likely are you to attend ICUR next year?



Answer	%	Count
Not at all likely	23.5%	40
Moderately Likely	30.6%	52
Very Likely	39.4%	67
No answer	6.5%	11
Total	100.0%	170

Q11) What were your greatest lessons or take-aways from the conference?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 141 respondents answered to this question; some mentioned more than one take-away. The sum of the category counts is 164.

The most often cited take-aways are:

1) Networking/interpersonal skills
2) How to present research/posters
3) Learn about students' research
4) Graduation school info
5) Learn about fields and types of research

A few criticisms were received and are indicated in red text.

CATEGORIES OF COMMENTS	COUNT
Networking/interpersonal skills	26
How to present research/posters	23
Learn about students' research	15

Graduate school info	13
Learn about fields and types of research	13
Students' positive response to poster presentation experience	10
Career guidance	9
How to create a poster	5
Learn about educators' research	5
Learn about new opportunities	5
Not specified	4
Value of research	4
Common challenges	3
Learn about Idaho initiatives	3
Learn about research resources	3
Learn from industry professionals	3
Praise ICUR organization	3
Diversity of perspectives	2
Work hard/practice	2
Breakout sessions	1
Criticism: Choice of plenary speaker	1
Criticism: No take-aways	1
Criticism: Students engaged at poster sessions but not breakout sessions.	1
Criticism: Very little practical business solution research	1
How to better assist undergraduates with research	1
How to make the most of time as an undergraduate	1
Improving interview skills	1
Lightning talks	1
Need for greater faculty involvement	1
Need to consider demographics of attendees	1
Praise students and faculty	1
Time management	1

Q12) What changes in the ICUR would significantly improve the conference experience for you?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 80 respondents suggested a change; some made more than one suggestion. The total count of suggested improvements is 95. 90 respondents either did not answer this question or indicated they had no suggestions for improvement.

CATEGORIES OF COMMENTS	COUNT
Breakout sessions	43
Other logistics	17
Poster sessions	16
Conference talks	5
Networking	5
Abstracts	3
Discipline focus	3
Not specified	3
Total	95

Highlights:

- Breakout sessions:
  - 8 people suggested “better” (not specified) or more interesting sessions
  - 6 people suggested shorter sessions
  - 3 requested suggested the sessions should have more of a research focus
  - 3 respondents indicated the sessions need more preparation
- Poster sessions:
  - 3 respondents felt the poster sessions were too tight on space
  - 3 respondents said the sessions should be shorter
- Conference talks:
  - 3 people were displeased with the content by specific speaker(s)
- Other logistics:
  - 4 respondents mentioned better food
  - 3 respondents felt there was not enough time for lunch
- Networking:
  - 3 people suggested better/more networking opportunities
  - 1 asked for more higher education people with whom to network
- Abstracts:
  - 2 people felt the submission process is confusing
  - 1 respondent suggested a better revision process

- Discipline focus—conflicting suggestions were received:
  - 1 respondent disciplines other than hard science; 1 suggested the conference should be more accessible to non-STEM majors.
  - 1 respondent suggested more science content.

Suggestions by Category (sorted by the greatest number of mentions to the lowest):

CATEGORY > SPECIFICS	COUNT
Breakout sessions	***43***
Shorter sessions	6
Better talks/speakers - not specified	6
More research focus	3
Better preparation	3
More interesting sessions	2
Sessions were repetitive/had the same info	2
Speaker did not follow guidelines	2
Too much focus on graduate school; not enough on other programs	2
More content that is not available online	1
Panel with mentors and mentees	1
More undergrad focus	1
More diversity of content	1
Have concurrent sessions for faculty/mentors	1
More diversity of speakers	1
More seats/different arrangement in breakout sessions	1
Better/more networking opportunities	1
Panel size too large	1
Did not appreciate content of specific speaker	1
Panels were not useful	1
Disorganized	1
Have more higher ed people available for networking	1
More options	1
Funding opportunities	1
More equity and inclusion issues content	1
More info about specific grad schools opportunities	1
Other logistics	***17***
Better food	4
Not enough time for lunch	3
Better communication of registration process	2
Market to public	1
Have concurrent sessions for faculty/mentors	1
Better online organization	1
More content that is not available online	1
Better signage	1
Send reminders of deadlines and conference dates	1
Better/more communication of sessions and details before conference begins	1
Change dates of conference	1

Poster sessions	***16***
Shorter sessions	3
Too tight on space	3
Better arrangement for visibility	2
Organize by subject	1
Better preparation	1
Organize so presenters have the opportunity to see other poster presentations from the same day	1
Too loud	1
Disorganized	1
Better/more networking opportunities	1
More faculty available for feedback	1
More time to present	1
Networking	***5***
Better/more networking opportunities	3
Have set time to talk to speakers	1
Have more higher ed people available for networking	1
Conference talks	***5***
Did not appreciate content of specific speaker	3
Speaker did not follow guidelines	1
Add high school focus	1
Not specified	***3***
More social science, less STEM	1
(blank)	1
Need for greater faculty involvement	1
Abstracts	***3***
Submission process is confusing	2
Better revision process	1
Discipline focus	***3***
Include disciplines other than hard science	1
More science content	1
Make accessible to non-STEM majors	1

FY 2019 Allocation of HERC Funds

		Total $4,163,200	Proposed Allocation
HERC IGEM			2,066,500
Infrastructure Funds			950,000
Matching Grants (EPSCoR Match)			800,000
Incubation Fund			0
Undergraduate Research			344,000
Administrative Costs			2,700
Total		**$4,163,200**	
Balance		$0	
IGEM Funds			$0
BSU	IGEM19-02		$666,500
ISU			$0
UI	IGEM17-01, IGEM 19-01		$1,400,000
LCSC			$0
Transfer to Targeted Research			$0
Total IGEM			**$2,066,500**
Research Infrastructure Funds			
BSU			$250,000
ISU			$250,000
UI			$250,000
LCSC			$200,000
Total Infrastructure			**$950,000**
Matching Award Grants			
NSF-EPSCoR (Managing Idaho's Landscapes for Ecosystem Services - $20M) (2013 - 2018)			$800,000
Total Matching Grants			**$800,000**
Targeted Research			
Idaho Incubation Fund (7th round)			
BSU			$0
ISU			$0
UI			$0
Transfer in			
Total Targeted Research			**$0**
Undergraduate Research			
One-time pending recommendation			$107,000
Undergraduate Research			$237,000

Total Undergraduate Research	**$344,000**
Administrative Costs	
FY19 Administrative Costs	$2,700
Total Administrative Costs	**$2,700**
Total Budget / Allocation	**$4,163,200**

NOTES

IGEM17-001

Security Management of Cyber Physical Control Systems
July 1, 2018 thru December 31, 2018
Final Mid-Year Report

University of Idaho
College of Engineering

Higher Education Research Council
Idaho Global Entrepreneurial Mission Program
Mid-Year Report

Grant Number IGEM17-001

Security Management of Cyber Physical Control Systems

January 15, 2019
The third and final mid-year report of a three-year project, July 2016-June 2019

University of Idaho, College of Engineering

Project Director and PI: Larry Stauffer, Dean

Co-PI's: Fredrick Sheldon, Professor, Computer Science
Brian Johnson, SEL Endowed Chair, Electrical & Computer Engineering
Michael Haney, Assistant Professor, Computer Science
Daniel Conte de Leon, Assistant Professor, Computer Science

Executive Summary

Cyber-attacks and intrusions are nearly impossible to reliably prevent given the openness of today's networks and the growing sophistication of advanced threats. Knowing the vulnerabilities is not adequate, as the evolving threat is advancing faster than traditional cyber solutions can counteract. Accordingly, the practice of cyber security should focus on ensuring that intrusion and compromise do not result in business damage or loss through more resilient solutions. We are creating a platform to facilitate and build complementary and multidisciplinary R&D capabilities to address these pressing problems. Our platform will incubate innovative products and services for safeguarding cyber physical control systems (CPCSs) that are ubiquitous and underpin key sectors of our economy. Early participation of industry will aid in vetting promising technologies. Better methods for assessment combined with more resilient systems design will safeguard against potentially immense economic impact currently being faced by Idahoan stakeholders.

Idaho SBOE Contact:

Cathleen McHugh, PhD
Chief Research Officer
cathleen.mchugh@osbe.idaho.gov
Tel: (208) 332-1572

Security Management of Cyber Physical Control Systems

July 1, 2018 thru December, 31, 2018

1 Summary of Project Accomplishments and Plans

This report presents the activities, accomplishments, and current status of the project titled "Security Management of Cyber Physical Control Systems." They are presented under the *four objectives* listed in our original project plan. We are mid-way through the third and final year (July 1, 2018 - December 31, 2018) of this three-year project.

1.1 Objective 1: Strengthen our capacity by adding key faculty and enhancing laboratories

In this third year of the project we have been able to add two new faculty members to the two we hired in year one. The hiring took longer than originally planned due to a very competitive job market for cyber security faculty. We have made substantial progress especially on deploying the new video technology infrastructure, continued laboratory enhancement projects, additional industry collaborations, producing research results, and planning for the post-grant period. A summary is as follows:

1.1.1 Faculty Searches

Our work plan called for the hiring of four faculty members to work in the area of cyber physical systems, two in electrical engineering and two in computer science. We planned to hire three in year one and one in year two of the project. We had a failed search for one of the positions last year but now all four positions are filled.

Our first hire was Yacine Chakhchoukh, a new assistant professor in Electrical and Computer Engineering is an expert in signal processing with experience in power systems cyber security operations. He earned a PhD in 2010 from Paris-Sud XI University/Superior School of Electricity, Supélec (Paris, France) with highest honors. Prior to joining the UI he was an assistant professor at the Tokyo Institute of Technology. He is located in Moscow.

Our second hire was Dakota Roberson. Dr. Roberson earned a PhD in Electrical Engineering from the University of Wyoming in 2017. During his studies, he was also a half-time intern for Sandia National Laboratories. Being located in our program in Idaho Falls is an excellent fit for his national laboratory background and is already helping us in our work with the Idaho National Laboratory. His area of expertise is in wide-area damping control to impact the effects of asymmetric time delay in geographically disparate locations, impact on coupling due to sensor/output collocation issues and forced oscillations in the wide-area damping control environment. These situations matter because grid operators consider all these limitations as they develop control systems to be implemented in their jurisdiction. However, sensor/output collocation disparities may limit their ability to ever implement the control.

As a result of a national search we made our third hire for the project, Jia Song. Dr. Song's research focuses on cybersecurity, high assurance computing systems, and security policy design. She was a member of team CSDS, for the DARPA Cyber Grand Challenge, an international competition in automated binary vulnerability analysis and repair. Building all the tools from scratch, the team was able to qualify as one of the seven finalist teams for the August 2016 competition. As security is a concern in many different areas, Dr. Song is collaborating with researchers in other fields, such as cyber physical systems, and sociology, to provide her knowledge of cybersecurity into multidisciplinary research. She is supporting an NSF research project on securing smart power grids under data measurement cyber threats. Dr. Song was also involved in an NSA project to develop a collection of cybersecurity learning modules which include teaching materials and student laboratory exercises. This curriculum is being shared among universities and government agencies to provide education on cybersecurity.

Continuing last year's failed search, we have recently hired Constantinos Kolias for Computer Science in Idaho Falls. Dr. Kolias was most recently an Assistant Research Professor in the CS Department at George Mason University in Virginia, which he joined in 2014. His main research interest revolves around security and privacy for the Internet of Things (IoT). He is also active in the design of intelligent Intrusion Detection Systems (IDS) with a special interest in privacy preserving distributed IDS. In 2015 he created and released the first wireless dataset specifically intended for research in

wireless security, namely the AWID dataset. Today' AWID has been downloaded and used as a benchmark by hundreds of organizations and universities. Currently, he is developing non-intrusive, remote malware detection tools and techniques for IoT systems, based on involuntary side-channel emanations (e.g., electromagnetic emissions from the CPU and power consumption of the device) and is investigating the applicability of blockchain-based authentication methods in the IoT realm.

1.1.2 Graduate Students

Four graduate students worked as research assistants under the project: Ananth A. Jillepalli, Ibukun Oyewumi, Andrew Miles, and Maadhavi Sathu. We briefly describe the research work performed by each of these students below. Subsections 1.3.3 and 1.3.4 list the publications that have resulted from the research performed by these graduate students and faculty in the project.

1. Graduate student Ananth Jillepalli is pursuing a doctorate in Computer Science. Jillepalli is completing the development of the High-level and Extensible System for Training and Infrastructure risk Assessment (HESTIA) for Cyber-Physical Control Systems (CPCS). Identifying vulnerabilities in a critical infrastructure can be challenging without a high-level security policy specification. Yet knowing the security policy specification is not enough to eliminate vulnerabilities. Knowledge of possible attacks and respective defense measures are also needed to secure critical infrastructure. HESTIA is a holistic systems and behavioral modeling process and tool-set. A primary approach of HESTIA is to enable Cyber-physical Control System (CPS) engineers to model their system, behaviors, and security capabilities, or lack thereof, using an adversarial-based approach. The goal of HESTIA is enabling scalable and incremental system modeling for cybersecurity risk assessment and optimal system and device hardening strategy determination.

2. Graduate student Ibukun Oyewumi is pursuing a Master's degree in Computer Science. He is co-advised by Yacine Chakhchoukh and Daniel Conte de Leon. During the Fall 2018 semester Oyewumi worked on the design and development of the control system and cyber portions of the Power Laboratory component of the ISAAC ICS Testbed and also the network interconnection between the ICS Testbed laboratories.

3. Graduate student Andrew Miles is pursuing a Doctorate in Electrical Engineering. Miles is working on research toward the implementation of robust state estimators for power systems this past semester. Robust estimators provide resistance against cyber-attacks. He began the semester by continuing his education on data analytics and estimation theory. He has also worked in parallel in software programs such as MATLAB and Python to test new algorithms. The new algorithms learned (GM/MM/S/Tau) estimators are being further implemented in a power system software OpenDSS to show feasibility studies for real world applications. The power systems Lab equipped with the RTDS is very useful for the real-time evaluation of the developed algorithms.

4. Graduate student Maadhavi Sathu is pursuing a Master's degree in Electrical Engineering. Sathu is working on a Power Swing Blocking Scheme for Power System Disturbances with the Integration of Renewables. Power systems operate close to their nominal frequency under steady state conditions. During the power system disturbances like faults, line switching, loss of load, generator disconnection results in sudden change to electrical power, whereas the input mechanical power to generator remains constant. These disturbances cause oscillations in machine rotor angles which results in severe power flow swings. Based on the severity of the power system disturbance, system can remain stable and return to equilibrium state which is referred as stable power swing, on the other hand if there are severe system disturbances there will be a large separation of generator rotor angles, large power swings, large fluctuations of voltage and currents and results in loss of synchronization between generators which is referred as unstable power swing. Large power swings either stable or unstable causes unwanted relay operations at different locations which can cause major power outages or power blackouts. In modern digital relays, power swing blocking (PSB) function is available in distance relays to prevent unwanted distance relay element operation during power swings by differentiating between faults and power swings. Most PSB elements are based on traditional methods which monitors the rate of change of positive sequence impedance such as Conventional Blinder Schemes. The required settings for PSB scheme are difficult to calculate in many applications, particularly those where fast swings can be expected. One such application is integration of renewables such as Wind Generation, Photo-Voltaic Generation with the existing power system models where fast swings are expected which can't be detected with the existing methods. A new method has to be developed in order to detect the fast swings which could prevent unwanted relay operation. Application of these methods will be demonstrated using power system modeled on a Real Time Digital Simulator (RTDS).

1.1.3 Laboratory Enhancements

In our proposal we projected to enhance equipment and make capability and facility improvements. In the original proposal we planned to use the existing space dedicated to the Power Laboratory (PowerLab) and just enhance the equipment in it. But we took advantage of an opportunity presented by the Murdock Foundation to invest an additional $285,000 of their funding plus an additional $200,000 of other funding invested in Coeur d'Alene to create a distributed Industrial Control Systems (ICS) Testbed with locations in Moscow, Idaho Falls, and Coeur d'Alene. Below we briefly describe the purpose and the progress on designing, installing, or upgrading each of the components of the ICS Testbed.

The Testbed will enable research and development of novel and secure techniques and algorithms for securing today and tomorrow's Power Grid (PG) along with other types of Industrial Control Systems (ICS). Its major advantage is that it will enable researchers and engineers to perform and collaborate on ICS-specific cybersecurity research, development, and testing on a system that closely resembles current distributed critical infrastructure cyber-physical control systems. It will expose hardware-in-the-loop simulation, enable the capture and use of real operational data, integrate current and future components of the power grid and other industrial control systems, and enable realistic attack-defend scenarios for research, evaluation, and testing. The Testbed includes a Real Time Digital Simulator (RTDS) for enhanced power system transmission and distribution system simulation capabilities. We are evaluating options for making the Testbed available from non-UI locations such as BSU. This capability will significantly enhance our ability to demonstrate (in-situ) advanced Power Grid and Industrial Control Systems cybersecurity technology to Idaho industry partners.

The Testbed is planned to connect the following five laboratories to create a distributed cybersecurity control systems and smart grid testbed unique in the Northwest.

A: The Power Laboratory in Moscow, Idaho.

B: The RADICL-Moscow Cybersecurity laboratory in Moscow, Idaho.

C: The SCANVILLE Analytics and Visualization Laboratory in Moscow, Idaho.

D: The RADICL-Idaho Falls Cybersecurity laboratory in Idaho Falls, Idaho.

E: The Industrial Control Laboratory in Coeur d'Alene, Idaho.

Enhancements to laboratories A, B, and C are well under way and will be completed soon. Equipment for the laboratories in Coeur d'Alene and Idaho Falls will be installed in February 2019.

A: ICS Testbed: PowerLab

The most significant accomplishment with respect to laboratory enhancements is the expansion of the Power Applications Laboratory (PowerLab) in Moscow. This laboratory underwent a major expansion from about 1,500 sq.ft. to 2,200 sq.ft. (Figure 1). The increased scope and capability of this change has come with a cost, in that the enhancements have taken about a year longer than we originally anticipated. However, this is a justified price to pay for the benefit we are gaining.

The space for the PowerLab section of the ICS Testbed was remodeled and completed the end of November, two months behind schedule because of asbestos abatement in the new space. We have worked with the Schweitzer Engineering Laboratory (SEL) Engineering Services Division to design this portion of the ICS Testbed for performing research on cybersecurity of power and industrial control systems. A contract was given to Schweitzer Engineering Laboratories for the industrial control equipment and RTDS upgrade. The equipment started to arrive in December 2018, as shown in Figure 2. The existing RTDS and associated amplifiers were moved to the PowerLab and test equipment was connected to the RTDS as shown in Figures 3-6. The upgraded RTDS equipment is shown in Figure 7, with the new RTDS NovaCor rack at the left. The existing rack was supplemented with additional processor cards donated by Schweitzer Engineering Laboratories.

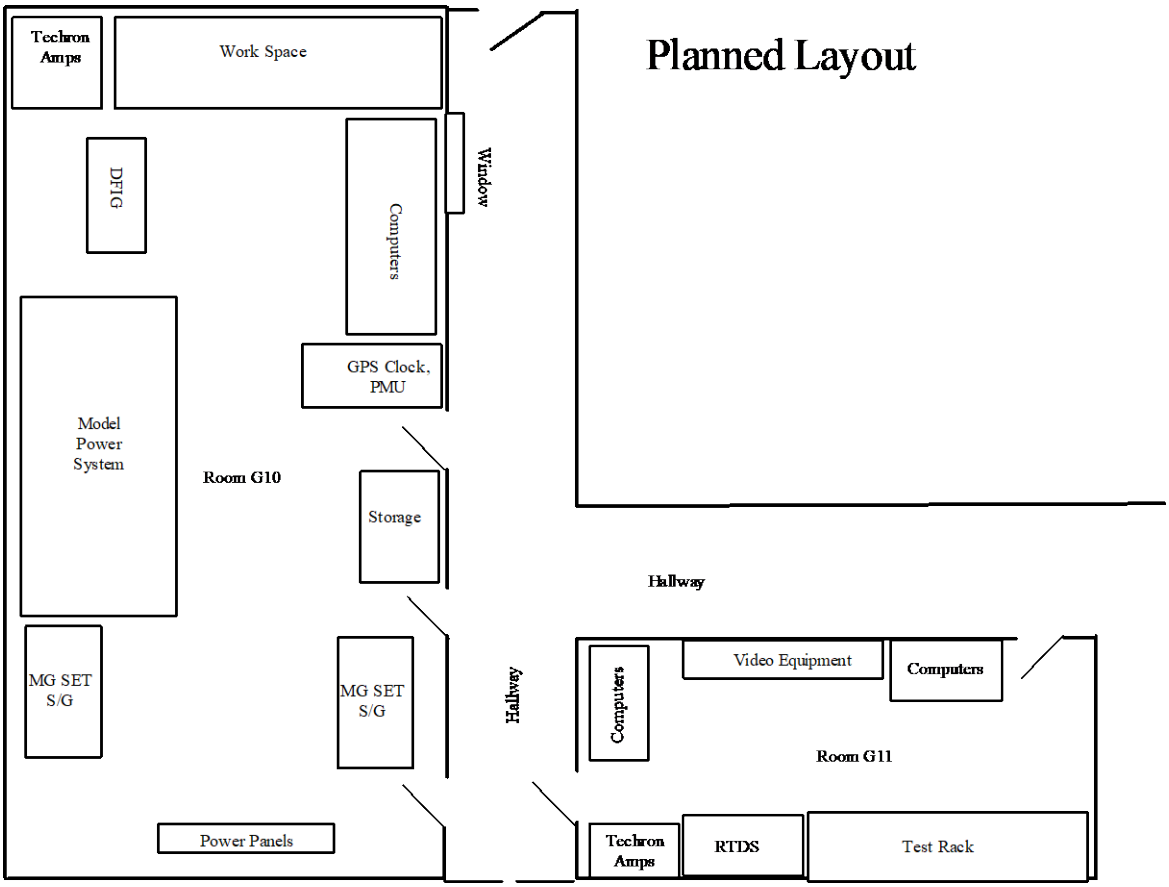


Figure 1: Illustration of the Power Systems Laboratory (PowerLab) Expansion.

Figure 2: Amplifiers moved and installed in the new PowerLab space.

Figure 3: Some of the test equipment for the expanded PowerLab along with new equipment racks.

Figure 4: Some of the test equipment for the expanded PowerLab along with new equipment racks.

Figure 5: RTDS, some of the test equipment racks and power amplifiers in the remodeled PowerLab space

Figure 6: Some of the test equipment for the expanded PowerLab along with new equipment racks (each rack will simulate a complete power substation's control).

Figure 7: PowerLab Component of the ICS Testbed with the addition of the new RTDS NovaCor rack (to the left).

B: ICS Testbed: RADICL Cybersecurity Lab:

The RADICL cybersecurity laboratory is the Reconfigurable Attack-Defend research and Instructional Computing Laboratory. This laboratory enables students and researchers to perform cybersecurity experiments in a controlled and isolated environment. Under the planned laboratory enhancements, we are enhancing the cybersecurity, computing, and analysis capabilities of this laboratory and integrating them into the ISAAC industrial control systems cybersecurity testbed.

Figure 8: Students working in the RADICL Cybersecurity laboratory before its renovation under this project.

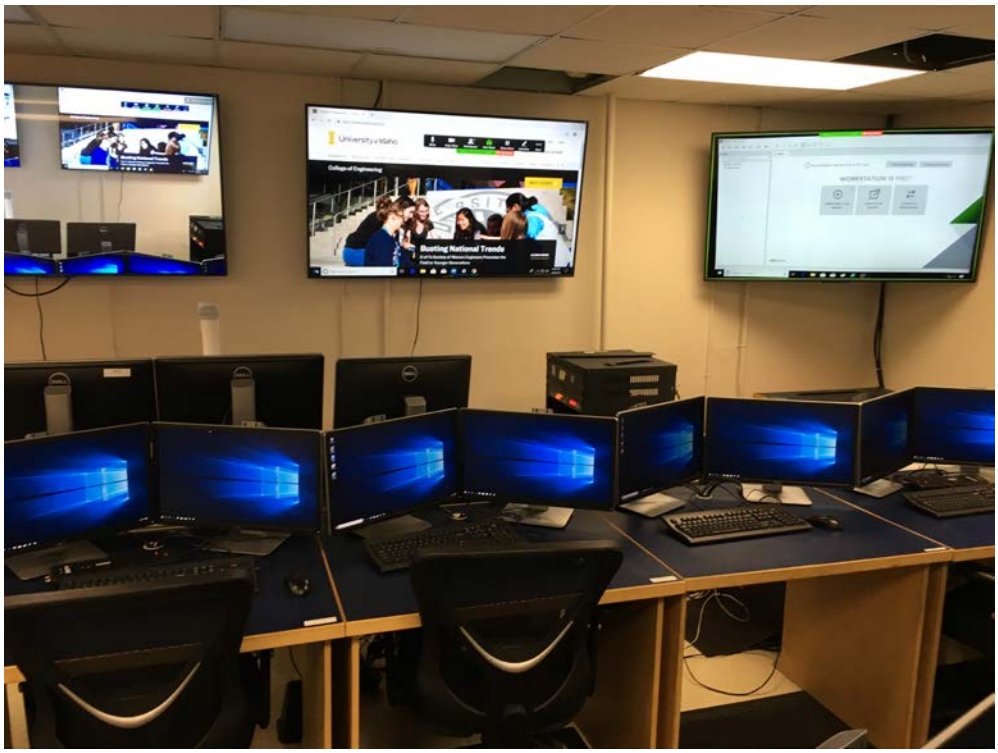


Figure 9: The RADICL Cybersecurity laboratory after its renovation during the Fall of 2018.

SCANVILLE: Securing Cyberphysical systems ANalytics, Visualization, IoT, and machine Learning Laboratory of Enquiry - A new component if the ICS Testbed.

This laboratory will be used to perform research on the architecture, design, implementation, and evaluation of systems for improving the cybersecurity of cyber-physical control systems, information technology (IT) and operational technology (OT) network and software systems, and Internet of Things (IoT) systems. This research includes, among other related activities, the architecture, design, implementation, testing and evaluation of software and combined hardware and software systems for analysis, machine learning, visualization, intrusion detection and avoidance, integration and testing including attack-defend scenarios, of networked digital systems with the purpose of improving the cybersecurity of said or related systems. This laboratory will also be connected to the Idaho Cybersecurity testbed through a dedicated high-speed fiber network.

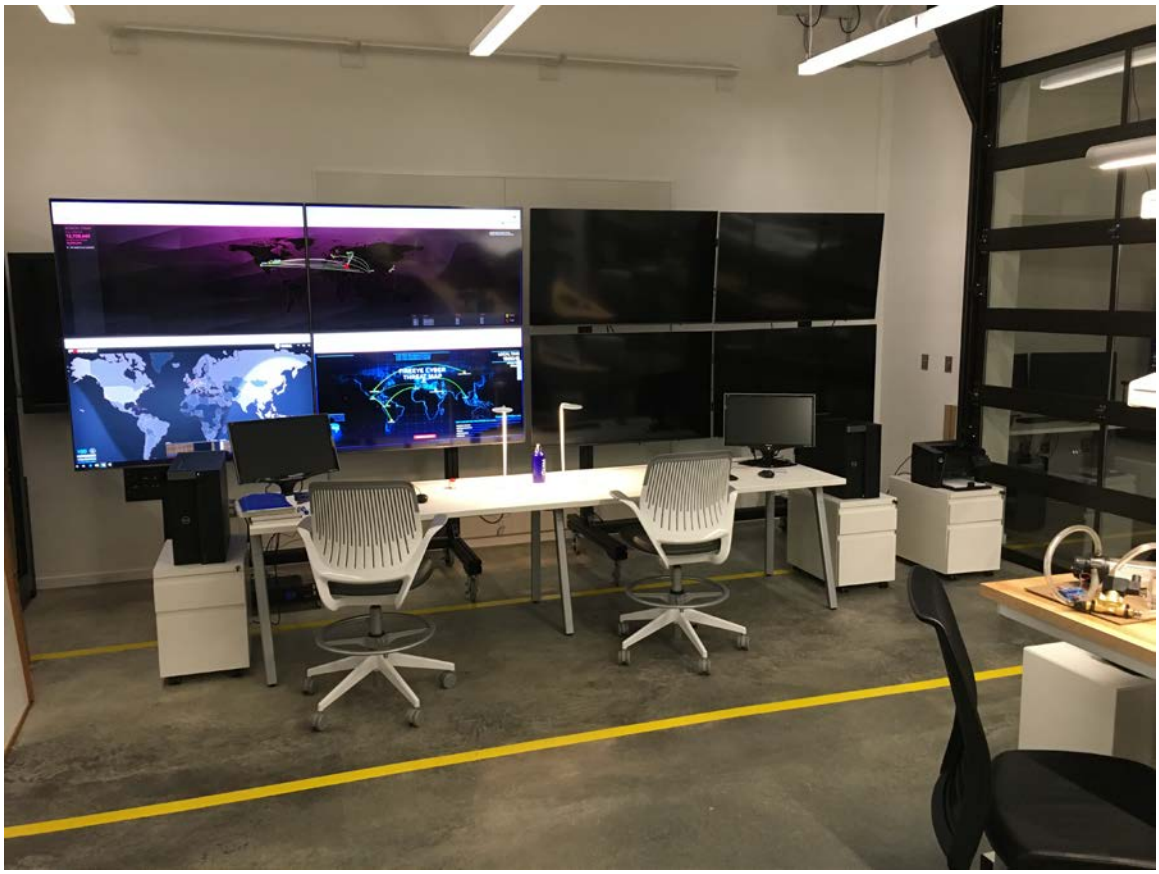


Figure 10: The SCANVILLE Screen Wall (each screen is a 55 inch 4K high definition TV).

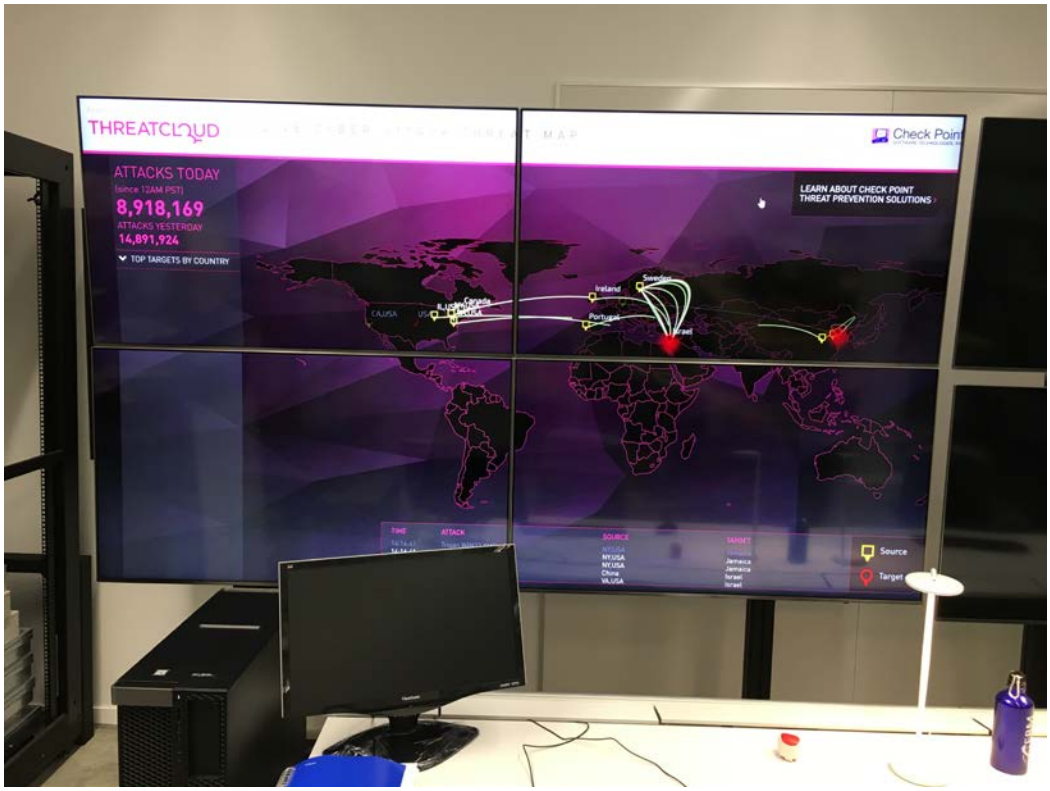


Figure 11: The SCANVILLE Screen Wall - Close Up.

Figure 12: The SCANVILLE Workstations.

D-E: ICS Testbed: Industrial Control and HMI Labs (Coeur d'Alene and Idaho Falls):

We are currently developing the nodes in Idaho Falls and Coeur d'Alene through a contract with Ameresco Inc. Each installation will have an identical Human Machine Interface (HMI) and control system. These are specified as:

1. Single Wonderware HMI running windows OS PC using a virtual machine.
2. (3) PLC supporting Modbus and DNP3 Ethernet protocols from HMI to PLC
    a. AB 1400 PLC- DNP3.0
    b. Automation Direct Dumore BRX PLC- Modbus
    c. Productivity 1000 PLC includes IO simulator
3. Small OIT terminal to read and write variables to PLC's.
4. Network switches and video hubs to extend application to a training video monitor touch screen.
5. Power hub for Ethernet
6. BOX PC with hosted virtual MS OS for Wonderware SCADA HMI
7. All programing development software to be included on BOX PC
8. Kobalt workbench for above stated equipment to be mounted- with caster wheels

The assets that are controlled by this system will be different in both locations. In Idaho Falls the security asset to be controlled will be related to a nuclear reactor. In Coeur d'Alene the security asset to be controlled will be a robotic manufacturing system. In both cases the plan is to integrate these devices into the IDC cybersecurity testbed.

Figure 9 shows a similar system currently being assembled at the vendor facility. Installation is scheduled for late-September. One of the benefits of this system is the flexibility it provides with the Wonderware software platform. Wonderware is the current industry standard.

Figure 13: Kobalt workbench with HMI and PLC for Asset.

1.2 Objective 2: Strengthen collaboration with Idaho industry and Idaho Universities

Our team had numerous on-going and one-time collaborations with industry and other universities. Some of these collaborations are listed below.

1. Brian Johnson has had weekly meetings with Craig Rieger and Tim McJunkin from the INL related resilient control of critical infrastructure. Efforts included:

(a) Ongoing research project as part of DOE Grid Modernization Lab project related to resilience metrics for power distribution systems, which ended September 2018.

(b) Collaboration on an ongoing LDRD proposal related to cybersecurity for industrial control systems, with collaboration from Virginia Commonwealth University. UI funding for year three was increased by $31,000 over the original budget.

(c) Collaboration course ECE 469/569: Resilient Control of Critical Infrastructure with collaboration between UI, ISU, WSU, UNR, and INL along with some interaction with Naval Post Graduate School, Weber State University, and Boise State University. Yacine Chakhchoukh coordinated the class from the UI this year.

(d) Helped organize a Resilient Controls track for the IEEE Industrial Electronics Society Annual Meeting (IECON), October 21-23, 2018 in Washington DC. Brian arranged for Scott Manson from Schweitzer Engineering Laboratories to be an invited keynote speaker for the track.

2. Brian Johnson and Dakota Roberson had monthly meetings with engineers from ABB Corporation Corporate Research, University of Illinois, Argonne National Lab and Bonneville Power Administration as part of a project addressing cybersecurity for HVDC transmission systems. They also participated in the DOE Cybersecurity for Energy Delivery Systems (CEDS) Peer Review meeting in Washington DC in November 2018 as part of this project.

3. Dakota Roberson and Brian Johnson coordinated an article titled “Improving Grid Resilience Using HVDC” which had contributors for Argonne National Laboratory, University of Illinois Urbana-Champaign and support from ABB. The article was an invited contribution a special issue of IEEE Power and Energy Magazine.

4. Brian Johnson and Yacine Chakhchoukh have been investigators on a project with Avista Corporation looking at non-wire solutions that use sensors and controls to alleviate the need for new transmission lines to improve reliability of power systems at a lower cost. That project ended in August 2018.

5. Yacine Chakhchoukh, Daniel Conte de Leon, and Brian Johnson have been investigators of a project with Avista Corporation looking at developing a secure framework for transactive energy trading at the power distribution level.

6. Brian Johnson was invited to participate in a US DOE Peer Review on the “Future State of Protective Relaying,” July 18-19, Oak Ridge National Lab.

7. Brian Johnson and Maadhavi Sathu had weekly meetings with researcher from INL, Oregon State University and industry advisors as part of a project to develop a white paper for the US DOE setting research needs related protective relaying systems.

8. Brian Johnson was advisor for four industry sponsored senior design teams in the fall semester, one sponsored by Avista, one by Schweitzer Engineering Laboratories and two related to developing power lab capabilities related to this grant.

9. Daniel Conte de Leon was advisor for one senior design team during the Fall 2018 semester. This team is working on developing 3D visualization techniques with the objective of visualizing complex industrial control systems.

10. Daniel Conte de Leon was customer for a student building a Faraday Cage to enable research and instruction on wireless IoT and control system devices.

11. Jia Song attended the research and collaboration meeting with SEL to discuss possible collaborations on computer science and security related research topics. (Nov 29, 2018)

12. Michael Haney was selected for a fourth consecutive year to hold a Joint Appointment with the Idaho National Laboratory, maintaining a strong working relationship with the Cybercore Integration Center under the National & Homeland Security division.

13. Michael Haney and Dakota Roberson were selected to support the INL’s Cybercore Integration Center strategic planning meeting, representing UI along with Janet Nelson, VPR, Brad Ritts,

Associate VPR, and John Russell, UI's Associate Director of the Center for Advanced Energy Studies (CAES).

14. Michael Haney, Dakota Roberson, and Frederick Sheldon were each selected to receive a Summer Faculty award by the Center for Advanced Energy Studies (CAES) in July and August of 2018 in Idaho Falls.

15. Michael Haney was selected to serve on ISU's search committee for their new cluster hires in cybersecurity, data science, and electrical engineering for the ISU Polytechnic in Idaho Falls.

16. Michael Haney continues to serve on the Advisory Board member, Energy Systems Cyber-Physical Security program, Energy Systems Technology and Education Center (ESTEC), Idaho State University.

17. Michael Haney was invited to speak at the first BSides Idaho Falls cybersecurity conference and presented his work on developing open sourced threat intelligence in September 2018. He has now joined the BSides Idaho Falls advisory board to plan the second and future open security conferences in eastern Idaho.

18. Michael Haney was invited to speak at the Tulsa Cyber Summit, sponsored by the University of Tulsa and the George Kaiser Family Foundation to be held in March 2019 in Tulsa, Oklahoma. There he will present his ongoing research in the methods for preserving privacy in pervasive networking monitoring and large-scale surveillance.

19. Michael Haney was recently invited to join an $(ISC)^2$ task force for updating the Common Body of Knowledge and the exam for the Certified Information Systems Security Professional (CISSP) exam.

20. Michael Haney continues to direct the Nuclear Cybersecurity Working Group within CAES, cultivating university and industry connections across the state of Idaho, across the nation's nuclear sector, as well as with the International Atomic Energy Agency (IAEA).

1.3 Objective 3: Foster technology transfer and commercialization through technology incubation

During the first half of this third year we have had several proposals funded and others submitted for research in this area:

1.3.1 Funded Project Proposals

B.K. Johnson, "Supplement to Resilient Scalable Cyber State Awareness of Industrial Control System Networks to Threat: Power System Design and Testing," Idaho National Laboratory, January 2019 - September 30, 2019, $31,000.

B.K. Johnson and J. Alves-Foss, "REU Supplement for: Small: Securing Smart Power Grids Under Data Measurement Cyber Threats", Syracuse University (subcontract of NSF funding). January 1, 2019 - June 30, 2019, $7,999.

A.Zadeghol, H. Lei and B.K. Johnson, "Air-core Reactor Inter-turn Fault Detection, using Magnetic Field Sensors" Schweitzer Engineering Laboratories, $139,221.94.

B.K. Johnson, "Protective Relay Study," Idaho National Laboratory, August 1, 2018-November 30, 2018, $10,000.

Y. Chakhchoukh, D. C. De Leon, H. Hess, B. Johnson, H. Lei and A. Daffin, "Designing and Evaluating an Energy Trading System for Prosumers", Avista Corporation, August 1, 2018 - September 1, 2019, $89,771

Smart Grid Resiliency Seed Funding from Center for Advanced Energy Studies (CAES) at Idaho National Laboratory to provide UI CS/ECE support to engage INL, BSU, ISU and Univ. Wyoming in Larger Scale Extramural Bid, Submitted Feb. 13, 2018 to CASE, provides $30,000 (six months) to the UI Computer Science (CS). PI F.T. Sheldon, Co-PIs: Michael Haney, Yacine Chakhchoukh, Zouheir Rezki, Paul Titus [INL] and John Stubban [BSU] and Others; Purpose: Develop larger scale proposal to DOE/NSF during CY 2018 (see DE-FOA-0001897 Building EPSCOR-State/National Laboratory Partnerships)

1.3.2 Funding Proposals Submitted and Under Review

B.K. Johnson, "Tool for auto-generation of dynamic zone selection logic for busbar protection," Schweitzer Engineering Laboratories, January 2019-December 2018, $98,187.

J. Song, "CRII: SaTC: Automating Fuzzing Based on Grammar Detected from User Input", National Science Foundation, May 2019 – May 2021, $174,999.

J. Alves-Foss, J. Song, "Automated Vulnerability Detection and Repair", DHS, May 2019-April 2022, $910,484.80.

M. Haney, "GenCyber: Bringing the GenCyber Experience to Eastern Idaho," National Security Agency, May – September 2019, $99,870.

R. Christensen, M. Haney, et al. "2019 NEUP Infrastructure: Developing a NuScale Simulator for Multi-Institutional Research of Small Modular Reactors", Department of Energy Nuclear Engineering University Program, October 2019, $285,763.01.

M. Haney, et al, "2019 NEUP NE-1: Analysis and Design of Future Digital Instrumentation and Control in Gen IV Nuclear Power Plant Control Rooms", October 2019, $798,700.

1.3.3 Publications: Published or Accepted

J.M. Sotelo, J. Guitierrez, B.K. Johnson, P. Moreno, A. Guzman "Time Domain Parameter Identification of Transient Electromechanical Oscillations," Accepted for publication in COMPEL: The International Journal for Computation and Mathematics in Electrical and Computer Engineering.

H. Esponda-Hernandez, E. Vasquez, M.A. Andade, B.Johnson, "A Setting-Free Differential Protection for Power Transformers Based on Second Central Moment," IEEE Transactions on Power Delivery. Available Early Access. Digital Object Identifier: 10.1109/TPWRD.2018.2889471.

N. Fischer, B.K. Johnson, A.G. Miles, J.D. Law, "Induction Motor Modeling for Development of a Secure In-Phase Motor Bus Transfer Scheme," IEEE Transactions on Industry Applications. Vol. 55, No. 1, January/February 2019, pp. 203-2012. DOI: 10.1109/TIA.2018.2868763.

M. Abuagreb, M. Allehyani and B.K. Johnson, "Design and Test of a Combined PV and Battery System Under Multiple Load and Irradiation Conditions," Accepted for 2019 IEEE PES Innovative Smart Grid Technologies Conference North America." February 17-20, 2019, Washington DC.

A.Momen, B.K. Johnson and Y. Chakhchoukh "Parameters Estimation for Very Short Line Using The Least Trimmed Squares (LTS)," *Accepted for 2019 IEEE PES Innovative Smart Grid Technologies Conference North America."* February 17-20, 2019, Washington DC.

K. Eshghi, B.K. Johnson, C.G. Rieger, "Resilient Agent for Power Systems Operation and Protection," *IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society*. Washington DC, October 21-23, 2018.

H.S. Samkari and B.K. Johnson, "Multi-Agent Protection Scheme for Resilient Microgrid Systems with Aggregated Electronically Coupled Distributed Energy Resources," *IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society*. Washington DC, October 21-13, 2018.

P. Khaledian, B.K Johnson, and S. Hemati, "Power Grid Resiliency Improvement Through Remedial Action Schemes," *IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society*. Washington DC, October 21-23, 2018.

A.Corredor, H. Beleed, B.K. Johnson, H.L. Hess, "D-FACTS for Improving Reliability of the Transmission System During Contingencies," *Proceedings of the 2018 North American Power Symposium*, Fargo, North Dakota, September 9-11, 2018.

H.S. Samkari, H.L. Hess and B.K. Johnson, "Developing a Microgrid Energy Management Scheme for a Pacific Northwest City," *Proceedings of the 2018 North American Power Symposium*, Fargo, North Dakota, September 9-11, 2018

P. Khaledian, B.K Johnson, and S. Hemati, "Harmonic Mitigation and a Practical Study of Torque Harmonics in Induction Motor Startup," *2018 IEEE Power and Energy Society General Meeting (PESGM)*, Portland, August 2018.

S.R. Sathu, N. Fischer, B.K. Johnson, "New Protection Scheme for Type 4 Wind Turbines," *71st Annual Conference for Protective Relay Engineers (CPRE).* College Station, Texas, March 2018.

Ibukun A. Oyewumi, Ananth A. Jillepalli, Philip Richardson, Mohammad Ashrafuzzaman, Brian K. Johnson, Yacine Chakhchoukh, Michael A. Haney, Frederick T. Sheldon, and Daniel Conte de Leon. "ISAAC: The Idaho CPS Smart Grid Cybersecurity Testbed." To appear in: Proceedings of the IEEE Texas Power and Energy Conference 2019 (IEEE-TPEC-2019), February 7-8, 2019, College Station, Texas, USA.

Ibukun A. Oyewumi, Ananth A. Jillepalli, Philip Richardson, Mohammad Ashrafuzzaman, Brian K. Johnson, Yacine Chakhchoukh, Michael A. Haney, Frederick T. Sheldon, and Daniel Conte de Leon. "Attack Scenario-based Validation of the Idaho ICS Smart Grid Cybersecurity Testbed (ISAAC)." To appear in: Proceedings of the IEEE Texas Power and Energy Conference 2019 (IEEE-TPEC-2019), February 7-8, 2019, College Station, Texas, USA.

Ananth A. Jillepalli, Daniel Conte de Leon, Ibukun A. Oyewumi, Jim Alves-Foss, Brian K. Johnson, Clinton L. Jeffery, Yacine Chakhchoukh, Michael A. Haney, and Frederick T. Sheldon. "Formalizing the HESTIA Process: Checking Consistency and Conflicts." To appear in: Proceedings of the IEEE Texas Power and Energy Conference 2019 (IEEE-TPEC-2019), February 7-8, 2019, College Station, Texas, USA.

Abercrombie, R.K., Ollis, B., Abercrombie, T., Jillepalli, A. and Sheldon, F.T., "Microgrid Disaster Resiliency Analysis: Reducing Costs in Continuity of Operations (COOP) Planning," To appear in Proceedings of the Hawaii International Conference on System Sciences (HICSS-52) January 7-11, 2019, Hawaii, USA.

Sheldon was invited to give a talk by Adolfy Hoisie (Brookhaven National Laboratory) and Behrooz Shirazi (National Science Foundation): Title of the talk: Analysis of COOP Planning Scenarios for a Microgrid to Enhance Sustainability and Resiliency," Sixth Symposium on Sustainable Energy and Computing (SSEC), Jan. 8-11 2019 at HICSS52 Maui, HI.

Y. Chakhchoukh and H. Ishii, Cyber security for power system state estimation, in J. Stoustrup, A. Annaswamy, A. Chakrabortty, and Z. Qu (editors), Smart Grid Control: Overview and Research Opportunities, Springer, pp. 241-256, 2019.

H. Lei, Y. Chakhchoukh and Ch. Singh, "Framework of a benchmark testbed for power system cyber-physical reliability studies," International transactions on electrical energy systems. August 2018. Wiley Online Library.

M. Ashrafuzzaman, H. M. Jamil, Y. Chakhchoukh and F. T. Sheldon, "A Best-Effort Damage Mitigation Model for Cyber-Attacks on Smart Grids," 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), Tokyo, July 23-27, 2018.

M. Ashrafuzzaman, Y. Chakhchoukh, A. A. Jillepalli, P. T. Tosic, D. C. de Leon, F. T. Sheldon, B. K. Johnson, "Detecting Stealthy False Data Injection Attacks in Power Grids Using Deep Learning," 2018 14th International Wireless Communications & Mobile Computing Conference (IWCMC), Limassol, 2018, pp. 219-225.

M. McGregor and M. Haney, "Quantum Key Exchange Simulator," *22nd Colloquium for Information Systems Security Education* (CISSE 2018), June, 2018, New Orleans, LA.

M. McGregor and M. Haney, "Quantum Key Exchange Simulator," In *Journal of the Colloquium for Information Systems Security Education*, Edition 6, Issue 1, September, 2018.

R. E. Hiromoto, M. Haney, A. Vakanski, and B. Shareef, "Towards a Secure IoT Architecture," Elsevier Publishing, 2019.

1.3.4 Publications: Submitted and Under Review

Yacine Chakhchoukh, H. Lei, B.K. Johnson, "Diagnosis of Outliers and Cyber Attacks in Dynamic PMU-based Power State Estimation," *Submitted to IEEE Transactions on Power Systems.* December 2018.

H. Lei, J. Geng, B. Johnson, "Influence of Superconducting Fault Current Limiters on Travelling Wave Based Protection," *Submitted to IEEE Transactions on Applied Superconductivity.* November 2018.

A. Aljebrine, H. Lei, H. Hess, B. Johnson, J. Geng, "Superconducting Fault Current Limiter Application for Induction Motor Starting Current Reduction," *Submitted to IEEE Transactions on Applied Superconductivity.* November 2018.

A. Momen, Y. Chakhchoukh, B.K. Johnson, "Series Compensated Line Parameters Estimation Using Synchrophasor Measurements," *Submitted to IEEE Transactions on Power Delivery.* August 2018.

J. Hatton, B.K. Johnson, D. Roberson, and R. Nuqui, "Increased Grid Resilience Via Cyber-Secure VSC Multiterminal HVDC Systems," *Submitted to the 2019 IEEE PES General Meeting.* Atlanta, Georgia, August 2019.

J. Song, J. Alves-Foss, "A Fuzzing Tool Based on Automated Grammar Detection", Computers & Security, Dec 2018.

J. Alves-Foss, J. Song, "Revisiting Function Boundary Detection", USENIX Security Symposium 2019, Dec 2018.

John Peterson, R.A. Borrelli, and Michael Haney, "An overview of the methodologies for cyber security vulnerability assessments conducted in nuclear power plants," Journal of Nuclear Engineering and Design.

M. Haney, J. Benjamin, and R. A. Borrelli, "Cyberweapon Non-proliferation and Safeguards: an Approach from the Lessons Learned in the Nuclear Sector", American Nuclear Society Conference on Safeguards, June, 2019.

T. McLean, R. A. Borrelli, and M. Haney, "Cyber Security Modeling of Non-Critical Nuclear Power Plant Instrumentation ," International Conference on Infrastructure Protection, SRI International, March 11 – 13, 2019, Arlington, VA.

M. Haney, "Advances in Deceptive Systems and Honeypots for Threat Intelligence and Active Defenses in Critical Infrastructures," International Conference on Infrastructure Protection, SRI International, March 11 – 13, 2019, Arlington, VA.

1.3.5 Presentations

November 2018: Speaker: Krishnanjan Gubba Ravikumar, Schweitzer Engineering Laboratories, Title: Experience with Remedial Action Schemes.

November 2018: Speaker: Dwight Anderson, Schweitzer Engineering Laboratories, Title: Cybersecurity for Power Protection.

December 2018: Speaker: Sudeep Pasricha. Department of Electrical and Computer Engineering at the Walter Scott Jr. College of Engineering in Colorado State University, Title: Smart Software for the Internet of Future Things.

1.4 Objective 4: Strengthen and expand the workforce

During the Summer of 2018 at least 9 students conducted internships focused on cybersecurity. Organizations were these students participated were: US Department of Defense, Idaho National Laboratory, Pacific Northwest National Laboratory, and US Department of Homeland Security.

Also during the Summer of 2019, Michael Haney developed and hosted the 2nd Cybercore Summer Camp held in Idaho Falls, receiving support from the College of Eastern Idaho and Idaho National Lab's Cybercore Integration Center. The tuition-free day camp hosted high school students from across eastern Idaho for three days of hands-on learning projects and "hacking" activities to introduce students to advanced computing and cyber-physical systems programming. Plans are in place and a grant application has been submitted to expand future camps for beginners and advanced students as well as area high school teachers.

As a follow-up to the successful summer camp, Haney has worked with the College of Eastern Idaho and Compass Academy to develop and host after-school programs supporting cyber-physical control systems and embedded device programming and cybersecurity activities for local high school students, which we believe will greatly strengthen the future workforce by fostering interest and skills at an early age.

2 Summary of Budget Expenditures

This summary is an estimate only as final mid-point expenditures have not all posted.

Salaries	$245,000
Fringe	$70,000
Travel	$4,000
Operating	$55,000
Tuition	$22,400
Total	**$396,400**

3 Demonstration of Economic Development and Impact

3.1 Patents, copyrights, plant protection certificates received or pending

There are none at this time. We are developing a strategy to raise the bar of awareness concerning patents and copyrights (including software and intellectual property) and engage with industry to identify opportunities.

3.2 Technology licenses signed, start-up businesses created, and industry involvement

Karen Stevenson who is our College of Engineering licensing associate at the UI Office of Technology Transfer (OTT) spoke to the Department about the UI Strategic Plan as it relates to Faculty, Research and Sponsored projects and Invention disclosures. We are planning to engage the OTT in the future to increase awareness pertaining to UI's Strategic Planning and Program Prioritization Process and the Commercialization of our research outcomes including public/private entrepreneurial partnerships. All told, we want to increase our enrollments/retention in both our Undergraduate and Graduate programs to meet the needs of Idaho's industry; bring viable technologies to market as well as creating high-value jobs while increasing our research capacity, especially as it pertains to the IGEM objectives and overarching theme: Security Management of Cyber Physical Control Systems.

These discussions are planned as Colloquium Topics and for Departmental Faculty Staff meetings.

3.3 Private sector engagement

See Section III (c) above for a list of formal engagements per our Computer Science Colloquium Series. Also, refer to the section on "Strengthening and Expanding the Workforce" at Section III (4) above regarding Industry/Government engagements.

The IGEM team of Co-PIs engaged with the Murdock Charitable Trust (as described above) to leverage (match) IGEM funding that was earmarked for laboratory equipment upgrades that are designed to improve our capabilities in Cyber Security Data Analytics and Visualization.

3.4 Jobs created

None for the reporting period other than the new faculty hires.

3.5 External funding

Nearly a million dollars of funding beyond the IGEM grant has been secured to help meet the objectives of this project. Of this amount, $795,000 came from external sources and $202,000 of college of engineering funding was redirected. A significant factor was the funding provided by the Murdock Charitable Trust to enhance power security laboratory as described above.

4 Numbers of Faculty and Student Participation as a Result of Funding

Seven faculty and four graduate students were the primary participants on this project. In addition, numerous other faculty and staff assisted in the activities such as supporting the faculty search process and expanding the laboratories and improved audio/video connections around the state as outlined in the original project plan.

Primary Faculty	Primary Students
Larry Stauffer	Hari Challa
Rick Sheldon	Krishna Koganti
Brian Johnson	Mohammad Ashrafuzzaman
Michael Haney	Ananth Jillepauli
Daniel Conte de Leon	Maadhavi Saathu
Yacine Chakhchoukh	Andrew Miles
Jia Song	Ibukun Oyewumi
Constantinos Kolias	
Dakota Roberson	

5 Description of Future Project Plans

Plans for the future are to accomplish the deliverables of the four objectives as stated in our original proposal. Specifically, for the final semester we plan to:

- Continue our research work on developing tools and techniques for securing critical infrastructure systems.
- Expand use of the UI Cybersecurity Training and Operations Center in Coeur d'Alene (including security assessments)
- Expand activities to initiate a Resilience Research Incubation Center in Moscow.
- Conduct assessments with willing industry partners to better understand the threats and potential impacts of compromises associated with CPCSs.
- Increase our capacities to deliver education course work (both for credit and non-credit professional development) and research.

Perhaps the most impactful outcome of this IGEM project this quarter is that we started to prepare a proposal for the first BS and MS degree programs in Cybersecurity in Idaho. In November 2018 the Computing and Accreditation Commission of ABET introduced the first program-specific criteria for cybersecurity. Given the ABET process, these students will be educated according to the new nationally accepted standards. Through this program we project to be delivering hundreds of cybersecurity engineers to the workforce over the next several years. We plan to educate students in Moscow, Coeur d'Alene, and Idaho Falls and will explore on-line delivery options as well. This program will deliver the talent needed by industry to help secure their data and infrastructure and grow Idaho's economy.

IGEM Program

First 6-month Progress Report

Project Title:	Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management
Principal Investigator:	Dr. Karen Humes
Institution:	University of Idaho (lead) with subcontracts to Boise State University and Idaho State University
Grant Number:	IGEM19-001
Award Amount:	$700,000
Fiscal Period:	July 1, 2018 – June 30, 2019
Progress Report Submitted to SBOE:	January 1, 2019
Reporting Period:	July 1, 2018 – Dec 20, 2018

Table of Contents

1) Summary of project accomplishments for first reporting period and plans for the remainder of Yr 1:

The accomplishments and plans for the four primary tasks identified in the original proposal are summarized here (Tasks A-D). A summary of accomplishments for the overall project management and coordinated stakeholder engagement activities are also summarized below, listed as Task E.

Task A) Recovery of energy, nutrients, water and bioproducts from waste streams: bench to place-based pilot projects

Team: Erik Coats (UI, environmental engineering/molecular biology; emphasis on resource recovery from waste streams); Armando McDonald (UI, biomass conversion and bioproducts); Kevin Feris (BSU, algae-based resource recovery and microbial ecology))

Accomplishments this reporting period/Plans for next reporting period:

A note on staffing: As noted above, this task is being carried out by the joint UI/BSU team comprised of three Co-Is. It is the largest and most complex of our four major tasks, in terms of resources and personnel committed. Nearly all of the students planned to be hired in Year 1 have been recruited, including 1 Ph.D. student and 8 undergraduate students hired in the Coats' (Environmental Engineering) lab in Fall 2018 and 1 graduate student coming onboard in January 2019 in the McDonald lab to work on bioplastics. Some delay in getting the subcontract to BSU set up has prevented the expenditure of the funds for one graduate budgeted at BSU in Fall 2018. However, this has allowed a helpful re-examination by the team of the most effective assemblage of personnel types for accomplishing the important objectives of this grant, which go beyond that of traditional research (which is well-accomplished by faculty and graduate students) to include the vital component of developing relationships with potential commercial partners for future implementation of our research advances. The team feels that this latter objective would benefit from the creation of a Research Scientist position (funded partly by this initiative and partly by the BSU institutional funding) that would be filled by and occupied longer by someone with a broader experience base and better sense of private-industry constraints than is typically possible with a graduate student. Indeed, a central goal in conducting research that addresses societal problems is the eventual application of novel research-based solutions beyond the research laboratory. However, often even when research-based solutions are economically viable they may not reach the market or be applied beyond research focused studies. This scenario is often termed "The Valley of Death" which is a colloquialism describing the phase between research and successful application of innovation in a commercial context. Although many research active faculty have the intellectual ability and research funding to support development of economically viable innovations, rarely do they have the time and skills necessary to cross the "Valley of Death". We are pursuing a partnership between research-focused grant funding and institutional support (i.e. Boise State) to create a Research scientist position specifically focused on the research goals of this project and development of the relationships necessary to cross the "Valley of Death". We believe that personnel specifically focused on these integrated goals are necessary to elevate research-based solutions from the Bench to Market.

Meanwhile, however, the many students and several faculty members who have begun work on this task have made good progress on the three sub-tasks within this task, as reported below.

Sub-task i: Bench scale activities

a) Characterization of waste streams from a variety of producers and processors in the Twin Falls area (e.g., dairies, yogurt, cheese, and potato processors);

- Obtained and conducted preliminary analysis on agro-industrial wastes available in the Twin Falls area. Results are summarized below. Further investigations ongoing in remainder of Yr 1.

Entity	Flow (mgd)	BOD (mg/L)	TSS (mg/L)	FOG (mg/L)
AmeriPride	0.13	178.28	70.36	110.53
Chobani	0.80	144.97	164.22	24.16
City of Kimberly	0.30	302.56	285.07	24.59
Clif Bar	0.01	659.22	444.06	23.86
Eagle Eye	0.01	143.01	410.35	2.78
Glanbia	0.51	601.50	244.21	89.27
Independent Meat	0.11	84.34	91.58	17.33
KapStone	0.01	401.69	196.97	3.15
Lamb Weston	1.76	2305.13	510.47	93.24
Total	**3.65**	**1267.98**	**349.38**	**69.34**

b) Assessment of optimal process sequences (biological, chemical, physical, thermal) to recover energy, bioproducts (biofuels; bioplastics) and nutrients from mixed waste.

- Bench-scale bioreactor operations are set up and underway. Performance assessment is ongoing and will be continued in the second half of Yr 1. One current focus is analysis of process "success" vs. "failure." Stable operations of any resource recovery system at full scale demands intrinsic knowledge on what constitutes stable operation, and how unstable, or "failed," operations might be recovered. Investigations are being conducted using macro- and molecular-level methods.

- Phosphorus recovery from wastewater is best achieved through a process known as enhanced biological phosphorus removal, EBPR. Bench-scale EBPR operations are ongoing, with a focus on ascertaining the effects of key process operational criteria on maximal P recovery. Results will ultimately inform pilot and full-scale operations.

- Another current focus is on achieving stable nitritation in an activated sludge wastewater treatment system achieving carbon, ammonia-N, nitrite-N, nitrate-N, and phosphorus removal. Nitritation is a biological process whereby ammonia-N is oxidized only to nitrite. Process success will result in significant energy savings in wastewater treatment.

- Two of Coats' undergraduate students are investigating the production of bioplastics (polyhydroxybutyrate-co-valerate, PHBV) on fermented dairy manure. Results will inform operations of our pilot scale system for 2019.

- Bench scale algal investigations have focused on establishment of algal cultivars to be employed in testing the effluent streams deemed most economically viable as determined by the wastewater modeling and bench-scale reactor experiments being performed in the Coats lab. Based on these initial wastewater characterization and viability experiments we will determine the most opportunity mechanism for algal cultivation in our integrated system and initiate cultivation tests with individual or consortia of algal strains selected based on their ability to grow in the selected wastewater streams and based on their growth rates, yields, biomass characteristics, and economic potential. These experiments will be initiated in the January/February time frame.

Sub-task ii: Pilot scale assessments - Conduct pilot scale evaluations from mixed waste streams; implement/evaluate treatment resource recovery processes.

- Have hired a team of undergraduate students and started training in the laboratory, with a focus on operations and analysis of biological resource recovery systems that are part of the targeted pilot-scale systems. The undergraduate team, combined with 2-3 graduate students, will operate the UI scale model systems in 2019.

- Conducting hypothetical re-configuration of the Twin Falls wastewater treatment plant to integrate proximate waste streams and achieve resource recovery. Analyses are being conducted using SUMO process modeling software by Dynamita. Results will be used to inform 2019 scale model operations.

- As noted above the outcome of these pilot scale assessments and modeling will inform decisions about which types of algal cultivation systems to couple with the AD/PHA aspects of our integrated system and which algal cultivars/species to employ in our bench and pilot-scale tests. The pilot scale algal cultivation systems will be operated in 2019 in collaboration with the Coats and McDonald labs at UI.

Sub-task iii: Produce prototype products (bioplastic mulch film, biochar, biofuel) for evaluation.

- Ordered laboratory blown-film extruder system for preparing bioplastic films and expected to be installed February-March 2019.
- Hired 1 graduate student and will start spring semester 2019 to characterize the bioplastic generated and prepare and evaluate the bioplastic films.

Note on partnerships inherent in Task A: Partnerships with producers, processors and municipal treatment personnel are fundamental to all of these tasks. Team will build on existing relationships with Twin Falls wastewater treatment facility, Food Northwest, Chobani, Amalgamated Sugar, J.R. Simplot, Idaho Dairymen's Association, and Glanbia, and expand to new partners throughout this project.

Task B) Decision-support tools for industry and community leaders to quantify and visualize trade-offs among water, energy, land use and municipal growth

Team: Jae Ryu, UI, systems dynamics modeling, water resources; Karen Humes (UI, water/energy nexus, geospatial analysis

Accomplishments this period:

- Began the process of upgrading the existing Stella system dynamics model from an older version to the new Stella Architect, which has more features and is more user friendly.
- Reviewed the data that was included in the original version and identified data needs in order to make the model more current and representative of climate changes and drought that have occurred during the past ten years. Examples of these data include: precipitation, groundwater pumping, spring discharges, evapotranspiration, etc.
- Made a formal request for these data to the Idaho Department of Water Resources (IDWR) and are currently working with them on data needs.
- Completed a literature review of recent published research related to water resources, system dynamics modeling, etc. in preparation for completing the tasks.
- Team began brainstorming about potential scenarios for integrating energy components into the updated Stella Architect model.
- Initial meeting with irrigation expert to begin developing module that would describe energy use in irrigation based on key variables
- Attended Energy Policy Institute meeting at Boise State University in September to connect with regional energy experts
- Explored data sources and availability for information on energy use in irrigation

Plans for next reporting period:

- We plan to incorporate new features that are available in Stella Architect into the system dynamics model and user interface.
- We plan to perform a quality analysis of the most recent data available from IDWR and complete the integration process to bring the model up to date.
- We will begin exploring management options to incorporate into the model, such as water conservation, managed recharge, etc.
- We will be developing system evaluation criteria associated with new data inputs and potential uses for the expanded and update model, such as system reliability, vulnerability, resilience, etc.
- We will acquire and analyze data on energy use in irrigation
- We will complete the development of a module for the system dynamics model that quantifies energy use in irrigation for two meteorological scenarios (average and above average demand in a growing season) and number of acres with other key variable combinations (eg., crop type, irrigation source/type)
- We will begin incorporating supply side scenarios to quantify and address the uncertainty of the water/energy nexus in the Eastern Snake Plain Aquifer.

Task C) Technical innovations/sensing systems to reduce water/energy/nutrient use in targeted production systems:

Primary team members: Donna Delparte, (ISU, drone and satellite-based sensing systems) and grower partners.

Accomplishments this period:

Progress in the following task area has been made through the subcontract award to Idaho State University and included:

- Innovative thermal Unmanned Aerial System (UAS) platform assembled and tested for spring data collection
- Programmer/Decision Support Analyst hired (mid-Dec) for development of online interactive website sustainable decision support tool to facilitate growers access to satellite and drone imagery and associated products.
- Private sector participation has been established with several growers and crop inventory has been provided by ProGrow Consulting for building the above-described decision support tool for producers

Plans for next reporting period:

For the next reporting period, the team will focus on the continued development and testing of UAS platform and sensor combinations for data collection in the 2019 growing season. These integrated sensor data collection systems will be utilized in field-based pilot projects with our participating growers to provide rapid decision-making information to reduce water and nutrient loads through an online interactive decision support tool.

Task D) Engaging the present and future workforce in the adoption of new technologies

Team members for training (primary): Karen Humes, Erik Coats and partners at CSI, UI Idaho Falls and professional organizations such as Food Northwest, *Primary team member for drone outreach activities:* Jae Ryu (Idaho Drone League (I-Drone), Founder).

Accomplishments this period:

- Although significant engagement with food processors and producers has already begun (see more reporting on this in Task E below), the workforce training aspects of this task were intended (and resourced in our budget) to take place primarily in Yrs 2 and 3 of our project. However, the PI worked in this reporting period to design a survey to be made available to participants at the annual expo of our key partner (Food Northwest) in Portland, OR in January 2019 designed to solicit input on workforce training needs in the food processing industry.

- Co-I Jae Ryu began developing plans for his three I-Drone outreach events (high school students and general public) in the spring/early summer of 2019.

Plans for next reporting period:

- Implement survey at Food Northwest Expo in Jan 2019 on workforce needs in food processing, collate results and discuss/vet with stakeholder advisory committee in March 2019, described in more detail in the next task.
- Implement I-Drone outreach events in Moscow, Boise and Pocatello (possibly add Twin Falls if funds permit).

Task E) Overall Project Management

Accomplishments this period:

- Team meetings established, three held via videoconference (in addition to separate coordination by multiple Co-Is under individual tasks)
- Planning for stakeholder advisory committee meeting to be held in March in conjunction with annual team meeting, with Twin Falls as target location. The goal of these initial meetings will be to enhance existing relationships, build new ones, and importantly to build a sense of collaboration and shared vision with regard to the specific nature of the research capabilities we are developing and the outputs and products we target.
- First draft of stakeholder advisory committee list formulated and consists of representatives from producer and processing groups, contract engineers for municipal waste water treatment (including Idaho Dairyman's Association, J.R. Simplot Corp., Amalgamated Sugar, Food Northwest and others who wrote letters of support for the proposal), as well as key state agency representation (such as Idaho Dept of Water Resources) and at least one municipal representative.
- Team began draft of a project-wide prospectus to provide concise explanation of project goals, make clear the genuine desire to better understand stakeholder needs and "value proposition" to stakeholders for their engagement with our project.

Plans for next reporting period:

- Complete plans and issue invitations (Jan 2019) for first annual in-person stakeholder advisory committee meeting to be held in Twin Falls (Mar 2019) with additional quarterly progress meetings to be held by videoconference (beginning Jun 2019)
- Complete project-wide prospectus document described above (Jan 2019) and distribute widely to Idaho producers and processors
- Attend the annual expo of one of our key partners (Food Northwest) in Jan 2019 (Portland, OR) and participate in activities to further disseminate project goals and understand stakeholder needs in energy, water, and waste (see section below on potential Tri-State funding opportunities for continuation and expansion of work).
- Continue to hold monthly team meetings to monitor progress and facilitate coordination of all project tasks and stakeholder engagement activities.

2. Summary of budget expenditures for period just completed – report through Dec 20, 2018.

Note about burn rates at all three institutions: Burn rates for all three institutions are considerably lower for these first 5 months than they will be in the next reporting period for several reasons. Most importantly, the notification of the award in late July and then lag times in setting up subcontracts to ISU and BSU made for less than 6 full months of activity, although this will not impact our ability to utilize all the resources and meet all deliverables in Year 1. Additionally, due to the holidays and report due date of Jan 1, expenditures are reported only through those posted by Dec 20; full expenditures through Dec 31 will not post until the first week in January. Going forward, the burn rate at all 3 universities will be considerably higher in the last quarter of the next reporting period (eg., late March through the end of June 2019) because of these factors:

- Late spring/early summer field work
- Travel by team and for stakeholder participants to our annual meeting and first annual stakeholder advisory meeting in Twin Falls in late March 2019
- Summer salary for faculty members in May/June 2019
- Increased hours for graduate and undergraduate participants in May/June 2019

Expenditures at the UI – posted through Dec 20, 2018:

$ 40,853.00 Salaries (faculty summer and grad students summer/fall)
$ 9,563.25 Temp Help (undergraduate students)
$ 4,779.38 Fringe Benefits
$ 6,517.20 Travel
$ 24,920.11 Operating Expenses, including research supplies for bench scale studies
$ 10,134.29 Small equipment (<$5K) – computer and drones/cameras
$ 8,350.00 Tuition Remission (UI graduate students)

$ 105,117.23 Total UI Expenditures through Dec 20

Expenditures in subcontract to BSU:

Due to processing time (both setting up the subcontract in Aug/Sept and invoicing lag), BSU has not yet invoiced for expenses incurred to date, but this will not impact the timeline of project deliverables. Please see note under Task A about proposed modification in type of personnel to be hired at BSU.

Expenditures in subcontract to ISU:

Due to processing time (both setting up the subcontract in Aug/Sept and invoicing lag, ISU has not yet invoiced for expenses incurred to date), but this will not impact the timeline of project deliverables. An informal reporting from the ISU Co-I reports these expenditures:

$ 2,416.80 – student salaries
$ 202.54 – fringe
$ 1,760.08 – OE, including UAS supporting mounts, hardware, software, tablets, etc.
$11,867.75 – UAS platform, GPS and thermal camera

$16,247.17 – Total ISU expenditures through Dec 20

3. Demonstration of economic development/impact

- Patents, copyrights, Plant Variety Protection Certificates received or pending

Although not a direct outgrowth of the funding received on this grant beginning in July 2018, there was a patent filed by ISU in our reporting period on behalf of Co-I Donna Delparte and her collaborator on work of a similar nature to that being done by Dr. Delparte in this grant. The previous work on which the patent was based involved the detection of infected plants in potato fields; the work in this grant will be of similar methodology (detecting plant stress with the use of high spatial and spectral resolution sensors on drones and satellites), but the focus in this investigation is slightly different (the detection of nutrient and moisture stress with remotely sensed imagery). The patent is included here as an example of the likely future outcome of Dr. Delparte's work on this grant and her success in working with stakeholders to develop useful products and methodologies.

Patent filed on Nov 30, 2018 entitled: "Method and system for detecting and managing infected plants" Donna Delparte, L. Michael Griffel, Idaho State University. Cross reference - U.S. Provisional Patent Application No. 62/597,636 (ISU-001 PROV)

- Private sector engagement

Because every aspect of our work involves considerable private sector engagement, we have noted those engagements in each of our five tasks described in Section 1 (Accomplishments Plans for next reporting period).

- Jobs created

Programmer/Decision Support Analyst hired on Dec 16, 2018 (starting date) at Idaho State University

4. Numbers of faculty and student participation

Through Dec 20, the numbers of faculty, students and other researchers participating are as follows:

Faculty:	6 (4 UI, 1 BSU, 1 ISU)
Graduate Students:	4 (3 UI, 1 ISU)
Undergrad Students:	8 (all UI)
Research Scientists:	2 (1 UI, 1 ISU, both partially supported by this grant)

5. Description of future plans for project continuation or expansion

- The team is coordinating closely with the newly forming CAES entity (led by the UI but including other CAES partners) referred to as the Food Processing Innovation and Education Center (FPIEC). The vision for the center is for it to be a mechanism for collaboration between universities and private industry to develop next-generation technology and education programs for the Pacific Northwest food processing industry, with private industry eventually contributing to research driven by their needs. The collaborations between Idaho institutions, Idaho food processors and Idaho communities that are being supported by this IGEM grant, and

the beneficial results it will produce, should provide excellent examples to encourage more stakeholders to become involved in partnerships through the FPIEC in the future. Likewise, the FPIEC provides a mechanism to continue and expand upon the work begun in this IGEM.

- Some members of the team are also part of an ad-hoc working group organized by the VPRED at the UI to network with other land grant institutions in the Northwest (i.e., Washington State University and Oregon State University) to be mindful of collaborative opportunities for research funding in the arena of sustainable food production and processing and food/energy/water nexus, particularly from the USDA, DOE and NSF. Some of the largest grants awarded at the University of Idaho have been through these types of inter-institutional collaborations. This is one of many reasons that we highly value and are working to continue to build our partnership with Food Northwest, which represents processors in all three states.

6. Expenditure report

As noted in the Budget Summary section above, due to lags in setting up and invoicing from subcontracting institutions, the detailed expenditure report provided below is available at this time only on the portion of total spending at the University of Idaho.

'Process'
FWRITEM
'Output Line'
FWRITEM University of Idaho
Itemized Expenditures by Grant Code
From 01-JUL-2018 To 20-DEC-2018

Grant: SG2836 - 20-Dec-2018 09:21 AM

Salaries		
E4108 Summer Salary		
Coats, Erik	5395.20	
80.00 hours		
Ryu, Jae	7219.80	
126.00 hours		
E4109 IA/GA Salary		
Mellin, Jason	13032.80	
360.00 hours		
Thompson, Emily	8000.00	
320.00 hours		
Walters, Riveraine	7205.20	
160.00 hours		

		$40,853.00

Temporary/Irregular Help
E4135 Temporary Student
Alfaro Salmeron, Glenda 825.00
75.50 hours
Brouillard, Nicolas 1753.50
146.25 hours
Dolph, Kirsten 1957.50
189.00 hours
Gibson, Joseph 528.00
48.00 hours
Shaber, Jonathon 541.75
49.25 hours
Smoot, Lindsey 1050.50
96.00 hours
Tompkins, Nicole 2445.00
206.00 hours
Watabe, Shion 462.00
44.00 hours

$9,563.25

Fringe Benefits
E4280 Faculty CFR Benefit Expense 3342.98
E4282 Student CFR Fringe Expense 1436.40

$4,779.38

Travel
E5360 Personal Vehicle - In-State
07-SEP-18 I2024562 Ryu, Jae H. 367.01
16-NOV-18 I2038986 Coats, Erik Robert. 332.77
16-NOV-18 I2038986 Coats, Erik Robert. 21.00
E5365 Personal Vehicle - Out-of-State
09-NOV-18 I2037420 Coats, Erik Robert. 25.00
E5367 Rental Vehicles - In-State
25-SEP-18 J1218430 V00349140 Ryu, Jae H. 337.90
25-SEP-18 J1218430 V00349140 Ryu, Jae H. 28.05
04-OCT-18 I2030060 Ryu, Jae H. 67.02
08-OCT-18 J1219824 V00733798 Humes, Karen S. 149.76
E5380 Airfare - In-State
18-SEP-18 I2027040 Humes, Karen S.. 521.11
E5381 Airfare - Out-of-State
02-NOV-18 I2035887 Coats, Erik Robert. 485.60
E5392 Ground Transportation-Out-of-State

09-NOV-18	I2037420	Coats, Erik Robert.	205.12
E5396 Per diem - In-State			
07-SEP-18	I2024562	Ryu, Jae H.	81.00
18-SEP-18	I2027040	Humes, Karen S..	447.00
18-SEP-18	I2027040	Humes, Karen S..	90.00
03-OCT-18	J1219330	V00096579 Coats, Erik R.	756.60
04-OCT-18	I2030060	Ryu, Jae H.	126.00
16-NOV-18	I2038986	Coats, Erik Robert.	56.25
E5397 Per diem - Out-of-State			
06-SEP-18	J1216134	MC, from 820928 to 820922	840.52
13-SEP-18	J1217141	V00096579 Coats, Erik R.	1260.78
24-SEP-18	F0148395	GRT227262-Civil Envnmntl Engin	-453.96
27-SEP-18	F0148659	GRT227263 Civil & Environ ENGR	-783.35
03-OCT-18	J1219329	V00096579 Coats, Erik R.	1175.02
09-NOV-18	I2037420	Coats, Erik Robert.	255.00
E5399 Other Employee Travel			
26-OCT-18	I2034588	Mellin, Jason James.	102.00
09-NOV-18	I2037420	Coats, Erik Robert.	24.00

			$6,517.20

Operating Expenses

E5045 Photocopy Service			
03-DEC-18	J1225771	DS; UIB copier charges Nov 2018	162.54
E5060 Subscriptions			
29-OCT-18	I2034722	Ryu, Jae H.	129.00
E5070 Conference/Registration Fees			
12-SEP-18	Z0839536	0826 PACIFIC NORTHWEST CLEAN W 208-	530.00
25-SEP-18	Z0840303	0905 ACT*UNIV OF IDAHO 877-551-5560	135.00
25-SEP-18	Z0840303	0905 ASSN OF AMER GEOGRAPHERS 202-2	165.00
08-OCT-18	J1219824	V00733798 Humes, Karen S.	250.00
09-OCT-18	Z0840975	0924 WEF EVENT 703-684-2400 VA	725.00
31-OCT-18	J1222316	NR, CT to correct budget	179.00
E5152 All Other Services			
25-SEP-18	Z0840189	0910 MISTER CAR WASH #502 BOISE ID	7.00
E5199 Other Professional Service			
10-SEP-18	BKCK0818	$47.20-Smoot 820922	47.20
E5310 Technology - Services			
11-SEP-18	J1216650	ec; August18 Net Services	80.00
04-OCT-18	J1219448	ec; September18 Net Services	60.00
18-DEC-18	Z0844107	1204 DELL SALES & SERVICE 866-393-9	61.50
E5345 Testing/Grading/Inspecting			
28-AUG-18	Z0839291	0816 PAYPAL *BOISEAREARA 402-935-77	92.91
E5350 Other Technical Services			

12-SEP-18 Z0839536 0817 OETC 503-6250501 OR 149.02
E5410 Office and Administrative Supplies
12-SEP-18 Z0839536 0822 VANDAL STORES MOSCOW MOSCOW ID 86.94
E5465 Gasoline
25-SEP-18 Z0840189 0906 SHELL OIL 57444639603 GARDEN C 80.58
25-SEP-18 Z0840189 0907 EXXONMOBIL 47851928 IDAHO F 40.88
25-SEP-18 Z0840189 0907 PILOT_00350 MOUNTAIN HOME ID 19.10
25-SEP-18 Z0840189 0907 PILOT_00350 MOUNTAIN HOME ID 71.77
E5528 Resale - Computer Software
04-DEC-18 Z0843209 1113 OETC 503-6250501 OR 58.09
E5560 Technology - Supplies
12-SEP-18 Z0839536 0817 CDW GOVT #NTW9785 800-808-4239 39.31
E5650 R&M Sup - Other
04-DEC-18 Z0843545 1115 PAYPAL *PGNINTERNAT 402-935-77 6.08
04-DEC-18 Z0843545 1119 PAYPAL *ZORO.COM 402-935-7733 5.48
E5720 Educational Supplies
09-OCT-18 Z0840866 0914 THE HOME DEPOT #1806 BOISE ID 32.94
18-DEC-18 Z0844337 1124 AMZN MKTP US*M03012NW1 AMZN.CO
149.95
18-DEC-18 Z0844337 1202 AMAZON WEB SERVICES AWS.AMAZON 1.64
18-DEC-18 Z0844337 1203 AMZN MKTP US*M02PW3BH1 AM AMZN
29.83
18-DEC-18 Z0844337 1206 AMZN MKTP US*M08P72690 AMZN.CO 13.76
E5724 Research Supplies
24-AUG-18 I2021934 Coats, Erik Robert. 1669.70
24-AUG-18 I2021943 Coats, Erik Robert. 1174.50
24-AUG-18 I2021946 Coats, Erik Robert. 838.78
24-AUG-18 I2021980 Coats, Erik Robert. 742.00
24-AUG-18 I2021995 Coats, Erik Robert. 549.21
28-AUG-18 Z0839116 0810 QIAGEN INC 800-426-8157 MD 594.22
28-AUG-18 Z0839291 0812 AMZN MKTP US AMZN.COM/BILL WA 9.73
28-AUG-18 Z0839291 0812 AMZN MKTP US AMZN.COM/BILL WA 62.70
28-AUG-18 Z0839291 0813 AMAZON.COM AMZN.COM/BILL WA 5.28
28-AUG-18 Z0839291 0813 AMAZON.COM AMZN.COM/BILL WA 72.70
28-AUG-18 Z0839291 0813 AMZN MKTP US AMZN.COM/BILL WA 113.20
28-AUG-18 Z0839291 0813 GRAINGER 877-2022594 IL 33.98
28-AUG-18 Z0839291 0814 AMAZON.COM AMZN.COM/BILL WA 5.28
28-AUG-18 Z0839291 0814 AMZN MKTP US AMZN.COM/BILL WA 14.63
28-AUG-18 Z0839291 0815 AMZN MKTP US AMZN.COM/BILL WA 14.84
28-AUG-18 Z0839291 0816 AMZN MKTP US AMZN.COM/BILL WA 99.98
28-AUG-18 Z0839291 0816 AMZN MKTP US AMZN.COM/BILL WA 170.76
28-AUG-18 Z0839413 0804 TFS*FISHERSCI ECOM HUS 800-766 37.62
28-AUG-18 Z0839413 0807 TFS*FISHERSCI ECOM HUS 800-766 12.54
28-AUG-18 Z0839413 0808 PAYPAL *FUZHOUHUIJU 402-935-77 285.00

28-AUG-18	Z0839413	0810 SP * FILTROUS HTTPSFILTROUS CA	253.25
28-AUG-18	Z0839413	0813 PAYPAL *COL INT GRP 402-935-77	483.34
28-AUG-18	Z0839413	0814 FILABOT 802-505-6772 VT	84.77
28-AUG-18	Z0839413	0814 TFS*FISHERSCI ECOM HUS 800-766	224.51
28-AUG-18	Z0839413	0815 TFS*FISHERSCI ECOM HUS 800-766	228.20
28-AUG-18	Z0839413	0815 TFS*FISHERSCI ECOM HUS 800-766	101.90
28-AUG-18	Z0839413	0815 TFS*FISHERSCI ECOM HUS 800-766	54.96
28-AUG-18	Z0839413	0816 DRI*WAVEMETRICS IGOR PRO ELEME	275.00
28-AUG-18	Z0839413	0816 TECHNICAL GLASS PRODUCTS 440-6	174.40
28-AUG-18	I2022816	Coats, Erik Robert.	292.70
28-AUG-18	I2022831	Coats, Erik Robert.	192.91
29-AUG-18	I2023038	Coats, Erik Robert.	160.06
30-AUG-18	I2023162	Coats, Erik Robert.	62.15
30-AUG-18	I2023260	Coats, Erik Robert.	61.89
30-AUG-18	I2023268	Coats, Erik Robert.	215.64
06-SEP-18	J1216079	TNUM 324543 Walmart	14.42
07-SEP-18	I2024658	Ryu, Jae H.	465.99
12-SEP-18	Z0839996	0817 PAYPAL *CHENGUOQING 402-935-77	28.99
12-SEP-18	Z0839996	0818 TFS*FISHERSCI ECOM HUS 800-766	75.24
12-SEP-18	Z0839996	0820 PAYPAL *NEXTDAYAUTO 402-935-77	25.00
12-SEP-18	Z0839996	0822 PAYPAL *9265823 402-935-7733 C	17.00
12-SEP-18	Z0839996	0823 PAYPAL *JMEJAK 402-935-7733 CA	15.00
12-SEP-18	Z0839996	0823 PAYPAL *MAJINNA 402-935-7733 C	13.60
12-SEP-18	Z0839996	0823 TFS*FISHERSCI ECOM HUS 800-766	88.51
12-SEP-18	Z0839996	0825 TFS*FISHERSCI ECOM HUS 800-766	74.00
14-SEP-18	I2026110	Coats, Erik Robert.	426.81
19-SEP-18	I2027222	Ryu, Jae H.	147.12
19-SEP-18	I2027309	Coats, Erik Robert.	18.15
19-SEP-18	I2027325	Coats, Erik Robert.	60.22
25-SEP-18	Z0840195	0904 AMAZON.COM AMZN.COM/BILL WA	336.40
25-SEP-18	Z0840195	0906 AMZN MKTP US AMZN.COM/BILL WA	44.37
25-SEP-18	Z0840195	0908 THE HOME DEPOT 1806 BOISE ID	368.43
25-SEP-18	Z0840195	0909 THE HOME DEPOT #1806 BOISE ID	3.75
25-SEP-18	Z0840195	0909 THE HOME DEPOT #1806 BOISE ID	-3.15
25-SEP-18	Z0840355	0910 HACH COMPANY 9706631377 CO	61.57
25-SEP-18	Z0840613	0901 TFS*FISHERSCI ECOM HUS 800-766	63.17
25-SEP-18	Z0840613	0911 PAYPAL *DVBARGAINZ 402-935-773	299.00
02-OCT-18	I2029573	Ryu, Jae H.	115.82
02-OCT-18	I2029587	Coats, Erik Robert.	43.80
09-OCT-18	Z0840975	0919 QIAGEN INC 800-426-8157 MD	1173.35
09-OCT-18	Z0840975	0920 HACH COMPANY 9706631377 CO	2137.68
09-OCT-18	Z0840975	0927 AMZN MKTP US*MT96Y1XG0 AMZN.CO	15.99
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09-OCT-18	Z0841185	0917 PAYPAL *INDUSTRIALH 402-935-77	10.98

09-OCT-18	Z0841185	0918 PAYPAL *ALBERTFILTE 402-935-77	27.20
09-OCT-18	Z0841185	0921 PAYPAL *FRANKBACONM 402-935-77	761.00
23-OCT-18	Z0841490	1002 PALOUSE HABITAT FOR HUMAN MOSC	30.00
23-OCT-18	Z0841490	1004 AIREKASCIENTIFIC WAN CHAI	238.00
23-OCT-18	Z0841490	1005 GRAINGER 877-2022594 IL	149.20
23-OCT-18	Z0841490	1005 PAYPAL *ADVANCE OPS 402-935-77	125.00
23-OCT-18	Z0841490	1009 HACH COMPANY 9706631377 CO	572.62
23-OCT-18	Z0841490	1011 TFS*FISHERSCI ECOM HUS 800-766	292.70
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23-OCT-18	Z0841862	1003 AMZN MKTP US*MT3JB0820 AMZN.CO	207.69
23-OCT-18	Z0841864	0928 PAYPAL *RQ SURPLUS 402-935-773	22.40
23-OCT-18	Z0841864	0930 PAYPAL *STRADEFAREA 402-935-77	14.08
23-OCT-18	Z0841864	1001 PAYPAL *MARCHOFFMAN 402-935-77	98.81
23-OCT-18	Z0841864	1008 PAYPAL *MS AND A 402-935-7733	11.10
23-OCT-18	Z0841864	1009 PAYPAL *MROSUPPLY 402-935-7733	12.90
23-OCT-18	Z0841864	1009 PAYPAL *SCOTTDOCTEU 402-935-77	10.86
23-OCT-18	Z0841864	1011 PAYPAL *MOLLYJAMIE 402-935-773	15.49
02-NOV-18	I2035694	Coats, Erik Robert.	43.80
06-NOV-18	Z0842037	1011 TRI STATE OUTFITTERS MOSC MOSC	9.96
06-NOV-18	Z0842037	1013 TFS*FISHERSCI ECOM HUS 800-766	161.30
06-NOV-18	Z0842484	1014 PAYPAL *MORNINGHILL 402-935-77	81.40
06-NOV-18	Z0842484	1022 PAYPAL *SOLANOTRADE 402-935-77	133.94
08-NOV-18	J1223342	331082 PAYPAL *METALREMNAN 402-935-	17.75
08-NOV-18	J1223342	331083 PAYPAL *TUNDRASPECI 402-935-	20.30
20-NOV-18	Z0842648	1101 TFS*FISHERSCI ECOM HUS 800-766	420.33
04-DEC-18	Z0843350	1112 AMZN MKTP US AMZN.COM/BILL WA	-62.70
04-DEC-18	Z0843545	1112 PAYPAL *FRANKBACONM 402-935-77	479.70
04-DEC-18	I2041603	Coats, Erik Robert.	278.93
18-DEC-18	Z0844147	1203 HACH COMPANY 9706631377 CO	565.99
18-DEC-18	Z0844147	1206 TFS*FISHERSCI ECOM HUS 800-766	355.50
18-DEC-18	Z0844337	1123 AMZN MKTP US*M00LJ9FR2 AMZN.CO	172.28
E5725 Field Supplies			
28-AUG-18	Z0839291	0811 MY VINYL DIRECT 12089326803 ID	8.32
E5741 Med Lab & Tech Supplies			
04-SEP-18	U0129294	Chemstores/Alayat	12.51
14-SEP-18	U0129478	Chemstores/McDonald	29.14
24-SEP-18	U0129560	Chemstores/Asghar	2.26
25-SEP-18	U0129581	Chemstores/Asther	9.79
26-SEP-18	U0129593	Chemstores/Alayat	13.34
05-OCT-18	U0129714	Chemstores/Asghar	15.12
23-OCT-18	U0129878	Chemstores/Wang	4.36
06-NOV-18	Z0842484	1014 PAYPAL *LI YUN 402-935-7733 CA	8.64
06-NOV-18	Z0842484	1015 PAYPAL *HONGKONGYEE 402-935-77	15.76
08-NOV-18	J1223342	329408 PAYPAL *PHR INC 402-935-7733	176.00

04-DEC-18	Z0843545	1120 PAYPAL *GD5357117SH 402-935-77	24.88	
E5749 Other Specific Use Supplies				
20-NOV-18	Z0842725	1102 FS *WEBODM.ORG 877-3278914 CA	47.00	
E5920 Rent - Motor Vehicles				
18-SEP-18	J1217504	EA; Fleet vehicle rental 9/6-9/10	228.00	

				$24,920.11

Small Equipment (<$5K)				
E7815 <5K Technology Equip - Enterprise				
27-AUG-18	I2022204	Ryu, Jae H.	2543.98	
E7830 <5K Computer Equipment Other				
16-NOV-18	I2038975	Ryu, Jae H.	3372.68	
E7996 <5K Photographic Equipment				
07-SEP-18	I2024658	Ryu, Jae H.	2097.63	
29-OCT-18	I2034722	Ryu, Jae H.	2120.00	

				$10,134.29

Tuition Remission and Training				
E7140 Tuition and Fees - Grad Assistants				
13-AUG-18	J1213446	G1GB for 171-55579	744.00	
13-AUG-18	J1213446	SHI1 for 171-55579	899.00	
13-AUG-18	J1213446	T1GB for 171-55579	3932.00	
10-OCT-18	J1220157	G1HD for 142-24168	415.00	
10-OCT-18	J1220157	MPX1 for 142-24168	175.00	
10-OCT-18	J1220157	T1HD for 142-24168	2185.00	

				$8,350.00

Total Expenses	$ 105117.23

7. Commercialization revenue - None to report at this time

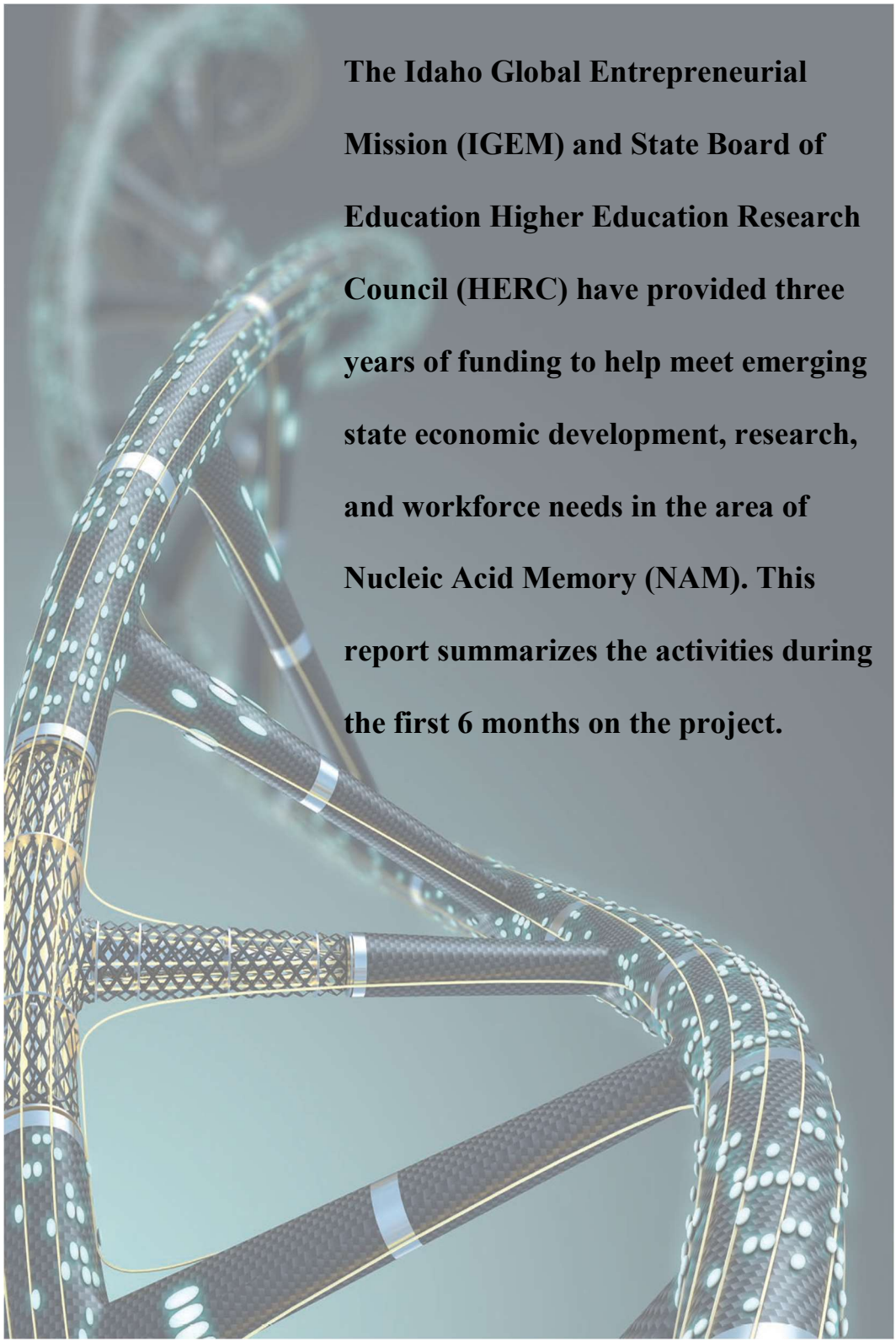
BOISE STATE UNIVERSITY

IGEM # 19-002: Nucleic Acid Memory

July 1, 2018 – January 1, 2019 Progress Report

Will Hughes
Chad Watson
Elton Graugnard
Tim Andersen
Reza Zadegan
Eric Hayden
Wan Kuang

I. Project Summary



II. Project Overview

In 2016, the digital universe produced 16 ZB (1 ZB = 1 trillion GB) of data. In 2025 it will create 163 ZB. These data, once generated, cascade through the information lifecycle — from primary storage media in the form of hard disks and solid-state drives to archival media such as tape. While the semiconductor industry maximizes the density, stability, and energy efficiency of electronic and magnetic memory, both are fast approaching their physical and economic finish lines. As envisioned by the new Semiconductor Synthetic Biology Roadmap, DNA-based massive information storage is a fresh start for memory manufacturing in the United States. According to our study with Micron, Harvard, and the Semiconductor Research Corporation (SRC), DNA has a retention time that ranges from thousands to millions of years, 1 kg of DNA can store the projected digital universe in 2040, and DNA's energy of operation is 100 million times less than current electronic memory. As a result, nucleic acid memory has become a global conversation, a national investment, an industrial opportunity, and a local strength in Idaho.

Our vision is to pioneer a digital data storage paradigm in Idaho by designing, building, and testing accessible, editable, and non-volatile nucleic acid memory (NAM) technologies that are inspired by DNA circuits and made possible by our innovations in DNA nanotechnology. With support from IGEM-HERC, we are creating a Nucleic Acid Institute Institute to meet critical innovation, economic, and workforce development needs in Idaho. To expedite our vision of Idaho becoming a global leader in NAM, five tasks will be met over the life of the IGEM-HERC: Task 1 – Create improved algorithms for coding information into data strands. Task 2 – Create a high-throughput, integrated analytical engine to design and select data strands using quantitative metrics based on an in-house, evolutionary algorithm. Task 3 – Create a cellular factory for manufacturing DNA scaffolds using a rapid design, build, and test cycle of genomes. Task 4 – Design and fabricate NAM storage nodes using the DNA scaffolds. Task 5 – Read and write arbitrary files into NAM storage nodes using super-resolution microscopy.

III. Summary of project accomplishments

Task 1 – Create improved algorithms for coding information into data strands.

- Kelsey Suyehira successfully defended her Master of Science in Computer Science in September 2018. Her thesis topic was entitled, *Using DNA for Data Storage: Encoding and Decoding Algorithm Development*. Briefly described, when encoding binary data into sequences of DNA, algorithms should account for biological constraints representing the idiosyncrasies of working with nucleic acids. In response, Kelsey created the REDNAM software package (a.k.a. Robust Encoding and Decoding of Nucleic Acid Memory). REDNAM includes a novel-mapping scheme that converts digital information into codons while accounting for important constraints when working with DNA. For example, it removes biologically active codes — such as start codons and some known promoter regions — avoids multiple repeats of unique nucleotides, and excludes repeating sequence strings. In doing so, Kelsey developed a schema mimicking how information has evolved to be efficiently encoded into natural DNA while also accounting for the errors that often arise when working with synthetic DNA. She also integrated her mapping scheme into a fountain code in an implementation that balanced information density with error correction. The result is that REDNAM recovers 100% of its data in spite of introducing random errors into the DNA. It also achieved a speed up of 2x for encoding and 435x for decoding digital information when compared to state-of-the-art fountain codes found in the literature. As shown below, Kelsey's thesis resulted in one publication and two conference proceedings that established a foundation for this award, with two more publications that are in preparation.

  - K. Suyehira, S. Llewellyn, R.M. Zadegan, W.L. Hughes, T. Anderson, "A Coding Scheme for Nucleic Acid Memory (NAM)," IEEE Workshop on Microelectronic and Electron Devices, pp 1-3, 2017.
  - R.M. Zadegan, K. Suyehira, S. Llewellyn, T. Andersen, W.L. Hughes, A Coding Scheme for Digital Data Storage in Nucleic Acid Memory (NAM), DNA 23, (September 2017), Austin, TX, USA.
  - R.M. Zadegan, K. Suyehira, S. Llewellyn, T. Andersen, W.L. Hughes, A Biologically Inspired Coding Scheme for Nucleic Acid Memory, FNANO, (April 2017), Snowbird, UT, USA.

Task 2 – Create a high-throughput, integrated analytical engine to design select data strands using quantitative metrics based on an in-house, algorithm.

- Michael Tobiason is completing his PhD in the Micron School of Materials Science & Engineering. With an expected graduation date in 2019, his dissertation topic is entitled, *Engineering Kinetically Uniform DNA Devices*. Briefly described, the relationship between DNA sequence and the rate of DNA reactions is not well understood. In response, Mike has hypothesized that observed kinetic variations in the literature arise due to unintentional base pairing in DNA. He has found that ranking model DNA devices based first on the size (in base-pairs) of the largest unintentional structure and then the count (number of structures of this size) reliably identifies sequences with improved kinetic reproducibility. To engineer DNA devices based on this principle, Mike created an evolutionary algorithm and software package called Sequence-Evolver. By engineering DNA devices with favorable interference profiles using Sequence-Evolver, Mike experimentally demonstrated that DNA kinetics vary by a factor of two or less when his sequences satisfy four conditions: (1) no intramolecular interferences longer than 2 base-pairs, (2) no intermolecular interferences longer than 4 base-pairs, (3) no stretches of consecutive cytosines or guanines longer than 3 base-pairs, and (4) no stretches of consecutive adenines or thymines longer than 6 base-pairs. Taken together, his findings support the hypothesis that kinetic variation arise due to interfering events and that kinetic reproducibility is possible through sequence optimization.

Task 3 – Create a synthetic biological factory for manufacturing DNA scaffolds using a rapid design, build, and test cycle of genomes.

- Steven Burden is completing his PhD in Biomolecular Sciences and is expected to graduate in 2020. His dissertation topic is the development of nucleic acid biosensors with allosteric fluorescence signals. Supporting the Vertically Integrated Project (see section VI), Steven is organizing the training of six undergraduate students to produce, purify, and ensure the quality control of single-stranded DNA scaffolds from a manufacturing perspective. During the Fall 2018 semester, the undergraduate students built basic synthetic biology research skills including DNA primer design and validation in polymerase chain reaction, digital design and sharing of

DNA sequences, bacterial transformation and cloning, gel electrophoresis, and DNA quantification and quality control using ultra-violet absorbance.

- A simple, cost-efficient, and time-saving method for the generation of modified and unmodified long linear ssDNA molecules up to 40 kilobases is under development using a method called asymmetric PCR (aPCR). This method enables direct synthesis of the single-stranded DNA from the template DNA and does not require purification steps. The single-stranded DNA fidelity has been verified by gel electrophoresis and by sequencing.

Task 4 – Design and fabricate NAM storage nodes using the DNA scaffolds.

- Sadao Takabayashi is completing his PhD in the Micron School of Materials Science & Engineering while working full time at Micron. He is expected to graduate in 2019 and his dissertation topic is *Patterning and Fabricating with DNA*. Foundational to this IGEM-HERC award, Sadao demonstrated high density and selective adsorption of DNA origami onto boron implanted silicon substrates made by Micron, which resulted in the below listed publication. He has since observed that surface adsorption is inversely proportional to the pattern feature size, and the smaller the pattern, the more pronounced the effect.
    - S. Takabayashi, S. Kotani, J. Flores-Estrada, E. Spears, J.E. Padilla, L. Godwin, E. Graugnard, W. Kuang, S. Sills, W.L. Hughes, "Boron-Implanted Silicon Substrates for Physical Adsorption of DNA Origami," International Journal of Molecular Sciences, vol 19, issue 9, number 2513, pp 1-12, 2018.
- Dr. Reza Zadegan, Assistant Research Professor on the project, has designed, built, and tested preliminary digital NAM (dNAM) structures. He has tested three iterations of rectangular NAM structures that have the capacity to contain 16-256 bits of binary information. Initial screening is underway to evaluate the resolution during super resolution microscopy, rate of structural errors, and direction/orientation of NAM. When completed, these parameters will inform future NAM prototypes.

Task 5 – Read and write arbitrary files into NAM storage nodes using super-resolution microscopy.

- In support of this task, Drs. Wan Kuang and Elton Graugnard are pursuing a new super-resolution microscope to push the ultimate optical resolution for NAM. As a starting point, Nikon demoed a microscope at Boise State which had an ultimate demonstrated resolution of 20 nm, which is lower

than the resolution of our in-house microscope of ~14 nm point-to-point. In response, Kuang and Graugnard visited Leica labs in the Bay Area and UC Davis to evaluate two Leica super resolution microscopy systems. The research team is now in conversation with MadCityLabs about real-time camera-based drift correction and the demo is pending. This is in alignment with them pursuing options for building an advanced super-resolution microscope at Boise State.

- Using their current SRM system, the team demonstrated staple strand yield improvement due to PAGE filtration and docking-sequence dependent PAGE filtration.

IV. Demonstration of economic development and impact

Demonstration of Economic Development and Impact	Number
External Funding	$ 1,500,000
News Releases	3 articles
Private Sector Engagement	14 companies
University Engagement	11 universities
Federal Agency Engagement	5 agencies
Industry Involvement	2 companies
Patents	0
Copyrights	0
Plant Variety Protection Certificates	0
Technology Licenses Signed	0
Start-up Businesses Started	0
Jobs Created outside of Boise State University	0

Shortly after the IGEM-HERC award, the National Science Foundation (NSF) in collaboration with the Semiconductor Research Corporation (SRC) jointly awarded the research team $1,500,000 to address the scientific challenges facing NAM technologies. The funding mechanism was called *Semiconductor Synthetic Biology for Information Processing and Storage Technologies*. Boise State was one of the few universities in the country to receive the prestigious award in the first round of competition. Other awardees included: MIT, Stanford University, University of Washington, and UT Austin. Prior to the release of this award mechanism, Drs. Will Hughes and Reza Zadegan coauthored the Semiconductor Synthetic Biology Roadmap in collaboration with the SRC, which helped steer the federal investments.

Because of the below listed consortium, industry involvement on the research project includes Gurtej Sandhu (Micron Technology Vice President) and Victor

Zhirnov (SRC Chief Scientist) who jointly serve as the co-chairs of the NAM Institute at Boise State University. According to Gurtej Sandhu, "*the leadership and innovation of this research team has brought them to the threshold of becoming a world class player in the research, development and education of nucleic acid memory*."

Industry Partners (14)	University Partners (11)	Federal Partners (5)
Autodesk GenoCAD Gingko Bioworks Globalfoundries IBM Intel International Data Corp Mentor Graphics Micron Microsoft Mubadala Technology Raytheon SynBioBeta Twist Biosciences	Boise State Boston University Brigham Young U. Columbia University Dartmouth Georgia Tech NC State University UCLA UIUC UNC Greensboro U. of Washington	- Army Research Office (ARO) - Department of Defense (DoD) - Office of Naval Research (ONR) - National Institute of Standards & Technology (NIST) - National Science Foundation (NSF) - Intelligence Advanced Research Projects Activity (IARPA)

For additional information, below are three news releases related to our work.

- **New NSF awards support the creation of bio-based semiconductors**, Sarah Bates, National Science Foundation, July 16, 2018. www.nsf.gov/news/news_summ.jsp?cntn_id=295968&org=NSF
- **How Micron's business could change dramatically from this research at Boise State**, David Staats, Idaho Statesman, September 27, 2018. www.idahostatesman.com/news/business/article218442875.html
- **Boise State University awarded $3.5 Million to research storing data on DNA**, Sherry Squires, August 28, 2018. https://news.boisestate.edu/update/2018/08/28/boise-state-university-awarded-3-5-million-to-research-storing-data-on-dna

In response to this momentum, Will Hughes has been invited to give a keynote talk on the Nucleic Acid Memory Institute at Boise State to VentureCapital.org (VCO) Investor's Choice Conference on February 20, 2019. The stage will be shared with senior leadership at Micron Technology. As a non-profit organization, VCOs mission is to improve the human condition by helping technology-based entrepreneurs "get started, find money, and change the world". Supported by the Wayne Brown Institute in Salt Lake City, VCO pulls together a powerful network of venture professionals who are actively engaged in advancing the impact of entrepreneurs in the United States.

V. Numbers of student, staff, and faculty participation

Classification	Number
Tenured or Tenure Track Faculty	5
Research Faculty	1
Project Manager	1
Graduate Students	6
Undergraduate Students	6

Critical to the success of any research initiative are the people that make up the project team. As part of the IGEM-HERC, we have six faculty (Will Hughes, Tim Andersen, Wan Kuang, Elton Graugnard, Eric Haden, and Reza Zadegan) and a project manager (Chad Watson). We have also transitioned three graduate students (Mike Tobiason – Task 2; Steven Burden – Task 3; Chris Green – Task 5) to this project and have recruited and hired three additional graduate students (Shoshi Llewellyn and Golam Md Mortuza – Task 1; Elijah Spears – Task 4 and 5). In addition, we hired Kelsey Suyehira, who is a recent graduate student from Computer Science that completed her Master of Science on the project. Ms. Suyehira helped transition graduate students focused on Task 1, while also working toward two project-related publications in which she is the lead author. In support of increasing the research productivity, the faculty are aggressively recruiting two postdoctoral fellows in the areas of nanofabrication and super-resolution microscopy to respectively work with Graugnard and Kuang. After an international search consisting of two advertisements, 42 applicants have applied, 8 finalists have been down-selected and 6 have been interviewed.

In support of this multidisciplinary team, a Vertically Integrated Project (VIP) was also launched in Fall 2018. As active participants in and co-owners of the Vertically Integrated Project courses called VIP 200, 400, 500 Bio-Innovations, undergraduate and graduate students enroll into a multi-year and multi-disciplinary research team that provides ongoing course and teaching credit. As of Spring 2019, six students have enrolled and are engaging in research activities aimed toward the production, purification, and quality control of new single-stranded DNA origami scaffolds. These students are being mentored by two previous VIP students with over 2 years of experience in the Eric Hayden lab, a fourth year PhD student, as well as the faculty members involved in the project. The students include sophomore Biology Major Ben Balzer, Junior Biology Major Madison Edwards, Hailey Jorgenson a senior pre-med student with a visual art minor, a senior Biology major Isaiah Keylor, and a senior Health Studies major Tia Senger. We are excited by the representation of women in this group,

the diversity of the majors and minors, and different levels of progress towards degrees. All students reported positive experiences, and all have signed up for the VIP course this semester (Spring 2019).

VI. Description of future plans

Task 1 – Create improved algorithms for coding information into data strands.

- Experimentally validate REDNAM by encoding and decoding digital information using synthetic DNA. The information will be read using commercially available next-generation sequencing. Once validated, the synthetic DNA will be randomly degraded under various doses to test REDNAM's ability to tolerate defects. Based on the performance of the tool, we will improve its robustness by accounting for better error correction techniques for insertion/deletion errors.
- Building on the success of REDNAM, we will create an optimal encoding/decoding algorithm specific to the digital NAM (dNAM). Concurrently, we will develop and publish a website for DNA-based encoding/decoding of data.

Task 2 – Create a high-throughput, integrated analytical engine to design select data strands using quantitative metrics based on an in-house, algorithm.

- Once published, the Sequence-Evolver software package will become an open source collaborative initiative available in the GitHub repository (https://github.com). It will also be posted on the website outlined above in Task 1. Once published, we will optimize the Sequence-Evolver software package to generate sequences specific to NAM, including but not limited to the scaffold strands, staple strands, and the strands used during super-resolution microscopy. In anticipation of needing to use the software tool for more complex jobs, Sequence-Evolver will be expanded to work on a supercomputer platform for larger NAM applications.

Task 3 – Create a synthetic biological factory for manufacturing DNA scaffolds using a rapid design, build, and test cycle of genomes.

- Building on the initial success of the VIP project, graduate and undergraduate students will continue to collaborate to design and build synthetic phagemids for single-stranded DNA synthesis, and to quantify single-stranded DNA harvested from bacterial culture.

- The design space for scaffolds is quite large, and students will be initially challenged to build larger scaffolds with high yield. Our initial goal will be to double the size of the scaffold with the same molar yield of single-stranded DNA as M13mp18, which is the gold standard. To maximize exploration, the students will be divided up into two teams, each organized by an experienced undergraduate researcher, and each with guidance and mentorship from PhD student Steven Burden and Dr. Reza Zadegan.

Task 4 – Design and fabricate NAM storage nodes using the DNA scaffolds.

- DNA origami will be designed for dNAM using in-house scaffolds. In addition, they will be tested in-house using our super-resolution microscope. Synthesis yield and defect rates for the origami structures will be quantified using super-resolution microscopy. In addition, initial origami structures will be designed for sequence NAM (seqNAM).

Task 5 – Read and write arbitrary files into NAM storage nodes using super-resolution microscopy.

- Incorporate upgrades to existing super-resolution microscope to both improve its resolution and extend its fluid handling.
- Toward higher resolution, the team will design and build a custom super resolution NAM reading platform capable of sub-10 nm resolution.

VII. Summary of Budget Expenditures

The below table summaries expenditures associated with the project. O&E has helped support the postdoctoral research scientist searches and the purchase of modified and unmodified DNA oligos. The oligos are used to assemble NAM blocks and to perform super-resolution microscopy studies. Funds were also allocated to purchase polymerase enzymes and primer oligos necessary for asymmetrical Polymerase Chain Reactions (PCR). The team is currently assessing super-resolution equipment to be purchased under capital.

Category	Expended
Faculty and Staff Salary	$32,344
Graduate Students Salary	$40,425
Fringe Benefits	$14,824
Graduate Student Tuition and Fees	$13,791
O&E	$17,839
Capital	0

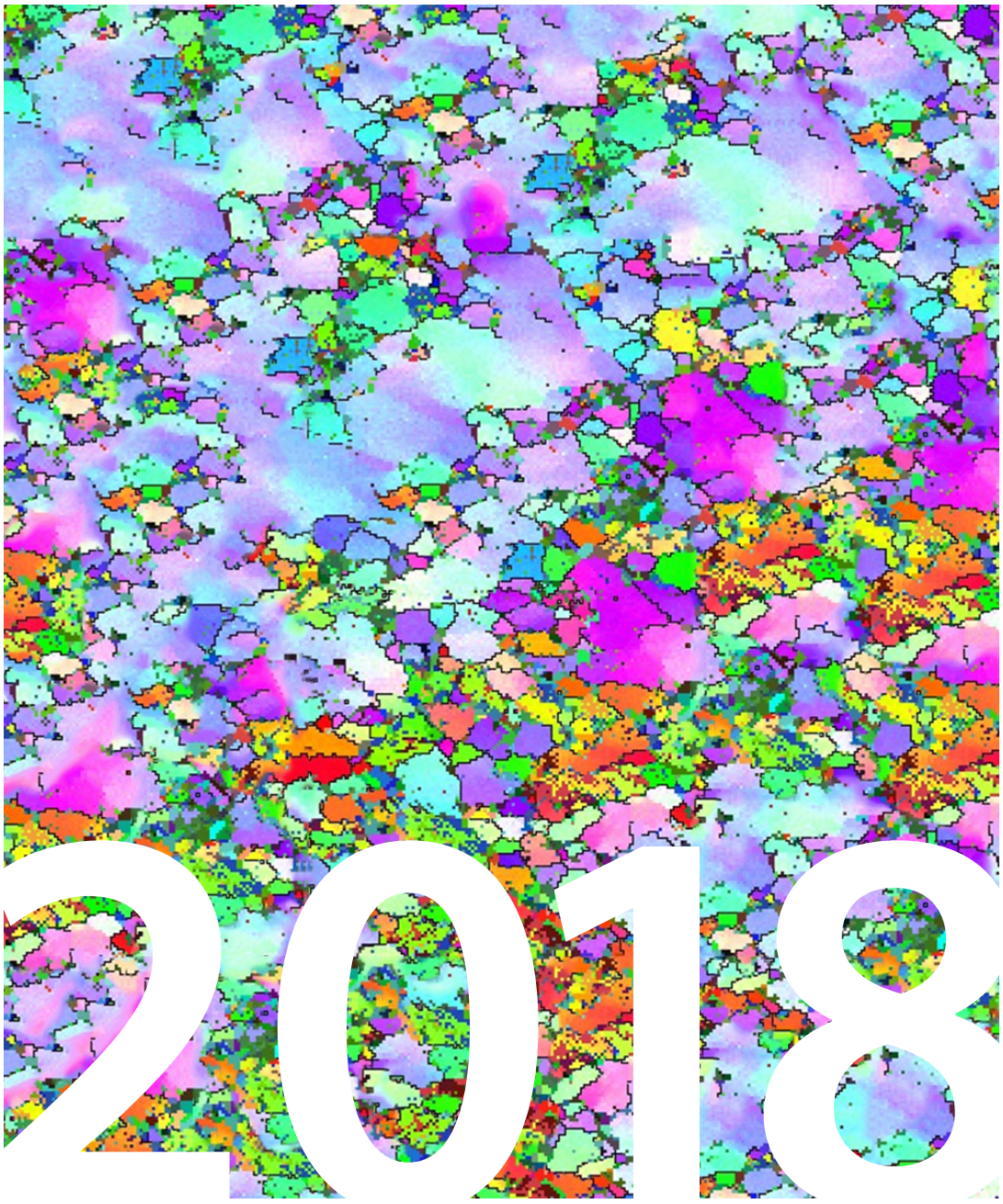
VIII. Commercialization Revenue

Commercialization	Revenue
None.	$0

IX. Additional metrics established specific to individual project

Metrics	Number
External Funding	$1,500,000
Software Tools Created and Initially Validated	3
Master of Science Thesis Awarded	1
Peer-Reviewed Publications	1
Manuscripts in Preparation	4
VIP Program Enrollment (grad and undergrad)	7
National and International Postdoc Recruitment	42

Listed above are specific, objective, measurable, and realistic performance metrics to gauge project success and economic impact, many of which have been distributed throughout this report and are consolidated here for ease of review.



2018

CAES ANNUAL REPORT

October 1, 2017-September 30, 2018

CAES
Center for Advanced Energy Studies

> I've never seen collaboration more successful than at CAES.
>
> Brad Little
> Lieutenant Governor, Idaho
> (elected Governor Nov. 6, 2018)

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ON THE COVER:
AN ELECTRON BACKSCATTER DIFFRACTION PATTERN OF A HIGH-TEMPERATURE, IRRADIATION-RESISTANT THERMOCOUPLE (NIOBIUM-ZIRCONIUM SHEATH) USED FOR TEMPERATURE MONITORING INSIDE A NUCLEAR REACTOR CORE. IMAGE CAPTURED ON A SCANNING ELECTRON MICROSCOPE INSIDE BOISE STATE UNIVERSITY'S CENTER FOR MATERIALS CHARACTERIZATION (BSCMC) IN THE MICRON SCHOOL OF MATERIALS SCIENCE AND ENGINEERING. COURTESY OF BRIAN JAQUES, PH.D.

DIRECTOR'S LETTER

I'll never forget the evening of August 5, 2012, when a NASA probe entered the Martian atmosphere, deployed a parachute, and landed the Curiosity Rover successfully on the Red Planet. People around the world gathered to watch and witness this historic accomplishment. But behind all the action were the herculean efforts of thousands of engineers, researchers, scientists, policy-makers, and support staff who helped make this historical event possible. Moments like these are meticulously prepared, the execution must be precise, and collaboration is more than a desire, it's a necessity. In fact, behind every great event, invention, or organization lies the effort of many.

With thoughts of achieving greatness on our minds, CAES took the opportunity this year to engage in a detailed strategic planning process that allowed us to pause – momentarily – from the daily shuffle of meetings, assignments, and project deadlines to reassess what makes us relevant, valuable, and necessary to our stakeholders. This inclusive and transparent process resulted in an ambitious, forward-looking strategic plan that sets CAES on a course for success over the next 20 years.

Our new strategy earned unanimous support from leaders at each of our five member organizations. The strategy focuses on collaboration and leveraging our collective resources, expertise, and facilities to act as a force multiplier in research, education, and innovation. It's this leverage that will allow us to take on significant technical challenges that will create a better energy future for the region, nation, and the world.

While our new mission, vision, and strategy set the course for the future, it's just as important to reflect on some of the year's other significant achievements. As you read this year's annual report, you'll see numerous highlights, accomplishments, and statistics that provide a glimpse of the value CAES provides its members and where we are headed in the future. You'll read about joint research that is solving critical challenges; you'll see the researcher, staff, and student connections and research wins made through CAES collaborations; and you'll hear about the positive impact we are having on our stakeholders at the universities and INL.

I hope you find this year's report engaging and inspiring. During the last fiscal year, it was the work of many researchers, faculty, staff, students, and countless supporters like you working together to make CAES successful. As an organization centered around collaboration, I truly value your input and feedback. At any time, please reach out to me or anyone on our leadership team. Thank you for your support during this process, and we look forward to hearing from you soon.

Sincerely,

Noël Bakhtian, Ph.D.
CAES Director

Collaboration Inspiring Innovation and Impact 2019-2039 CAES STRATEGY

CAES Releases New 20-Year Strategic Plan

Ten years ago, the Center for Advanced Energy Studies (CAES) was founded as a catalyst to activate world-class research assets at Idaho National Laboratory in combination with research universities in the region. CAES is focusing future collaborative efforts to discover and bring to market the approaches, technologies, and solutions to create measurable and lasting impacts for the people of Idaho and Wyoming, the nation, and the world.

CAES already benefits from a proud tradition, dedicated leadership team, broad community support, and public wins in the form of joint federal projects awarded, collaborative publications, joint appointments, and a wave of new and advanced facilities. As energy, environmental, and national security challenges persist, we believe we can be doing even more to positively impact the world's energy future.

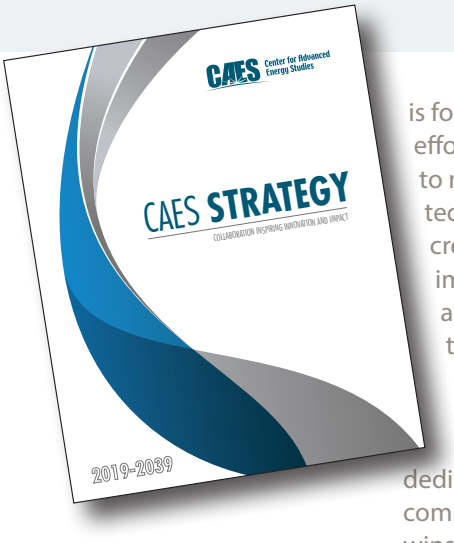
Thanks to your support, CAES spent the last fiscal year redefining its strategic direction through a series of stakeholder engagement meetings, listening sessions, focus groups, surveys, and internal discussions. Beginning in November 2017 and continuing through March 2018, CAES hosted five large working group meetings bringing together the leadership and stakeholders from all five CAES member organizations to discuss specific areas of focus. More than 500 people attended these forums, providing feedback and ideas, and

Vision

Our vision is to create a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact.

Mission

CAES is the collaboration that inspires innovation and impact by leveraging our collective capabilities to empower students, researchers, faculty, and industry to accelerate energy solutions.



To read the entire CAES strategic plan, visit www.caesenergy.org

helping craft CAES' major focus areas and strategic direction. Some of the ideas generated led to laboratory funding and the development of federal research proposals, white papers, and capabilities road maps.

Through the summer of 2018, the CAES leadership team worked diligently to capture the best ideas from the year of discussion and develop them into a comprehensive 20-year strategic plan. At least 2,000 hours were spent on this project, and while it was a challenging effort, our future is stronger for having gone through the process. On Nov. 7, 2018, the CAES Steering Committee approved the new strategy. Today, CAES researchers, faculty, staff, and students are working to implement the tactical actions that will lead to lasting, long-term results that elevate CAES' potential impact.

The new CAES strategy rests on three strategic pillars: Research, Education, and Innovation. These pillars set the foundation for a series of major deliverables that will be achieved through a concerted, multiyear effort leading to an unprecedented level of collaboration between researchers, faculty, students, staff, policy-makers, members of industry, entrepreneurs, and many more. Our efforts will focus on several grand challenges including nuclear energy; advanced manufacturing; cybersecurity; energy-water nexus; innovative energy systems; energy policy; and computing, data, and visualization. In each of these areas, there are stark challenges, but enormous opportunities we look forward to tackling together.

Over the next year, we will broadly share our strategy as we begin the long but necessary road toward implementation. We know that to achieve success, we must work together to accelerate research, develop the workforce of the future, and innovate technology for global impact. Our goal is to move the world forward toward a better energy future. We hope you'll join us.

3
PILLARS

7
FOCUS AREAS

20
YEARS

> Sakae Casting opened its Idaho Falls office … They have been busy collaborating with CAES to bring their unique technology to bear in the nuclear industry—it could greatly impact how we handle storage of spent fuel.

Rebecca Casper, Ph.D.
Mayor, City of Idaho Falls
2018 State of the City address

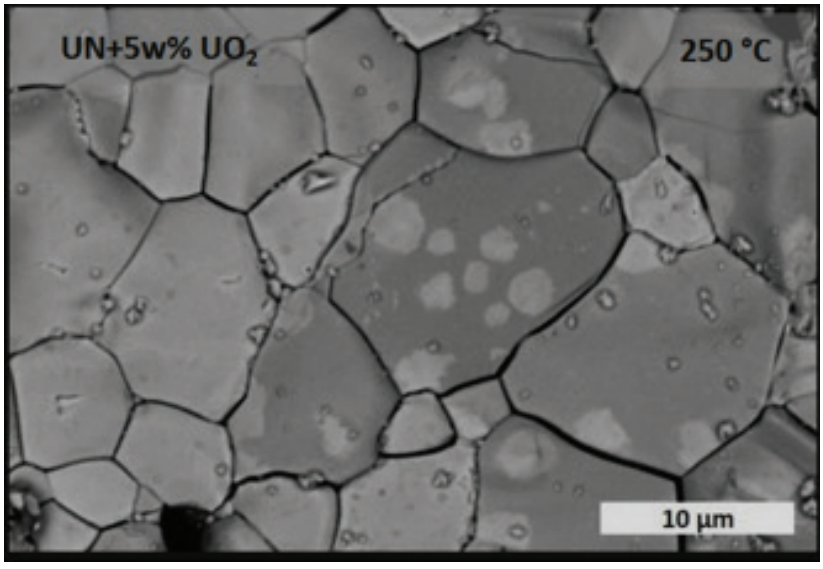
RESEARCH HIGHLIGHTS

CAES Research Team Wins $237,000 IGEM Grant for Spent Nuclear Fuel Storage Research

In 2018, a CAES research team was awarded a one-year, $237,000 grant from the Idaho Global Entrepreneurial Mission (IGEM) program. The funding was used to model heat-transfer properties for a new spent nuclear fuel storage cask that aims to reduce the amount of time irradiated nuclear fuel stays in water-cooled fuel pools. The project is led by researchers Bob Borrelli and Rich Christensen, both from the University of Idaho, with support from Boise State University's Brian Jaques, and Idaho National Laboratory's Piyush Subharwall.

Using computer-aided design software, researchers designed models of aluminum plates infused with boron – a material particularly suited for neutron absorption – capable of fitting inside a newly designed spent nuclear fuel cask. If successful, the plates and cask design will work together to provide additional layers of neutron and gamma ray shielding, while also cooling the spent nuclear fuel assemblies. This means spent nuclear fuel could be moved out of water pools and into dry storage faster than with the current cool and wait method.

This project also involved technical experts from Tokyo, Japan's Sakae Casting and Blackfoot, Idaho's Premier Technology, along with team members from the College of Eastern Idaho, and Table Rock LLC, a Virginia-based consulting firm focused on Nuclear Regulatory Commission compliance.



CAES Researcher Wins $300,000 Grant from DOE's Geothermal Technology Office

As more renewable energy sources are added to the electric grid, power plant operators must continually adjust output to match needs. Since the bulk of U.S. electricity is produced using large spinning turbines and generators powered by natural gas, coal, and nuclear plants, cycling the power flow on and off is time consuming and taxing on the machinery. A potential solution could come by storing excess heat energy in a dynamic earth energy-storage system, or deep underground battery. This concept was proposed by CAES researcher Travis McLing, who picked up a $300,000 grant from the U.S. Department of Energy's Geothermal Technology Office, to study the feasibility and methods for pumping excess power plant heat into briny, subsurface reservoirs located deep beneath the earth. The project involves several researchers, including McLing and Daniel Wendt from Idaho National Laboratory; Christine Dought, Nic Spycher, and Pat Dobson from Lawrence Berkeley National Laboratory; Dakota Roberson from the University of Idaho; and Fred McLaughlin from the University of Wyoming. Support for the project will also come from Rocky Mountain Power.

The surface sheath of a High Temperature Irradiation Resistant thermocouple after a ductility test as captured on a scanning electron microscope. The image is part of a collaborative research project between BSU and INL geared toward instrumenting nuclear reactor cores.

"The days are done when a single researcher can solve a problem alone. CAES is effective because it has a deep bench of talent to draw from, and I know there are some grants and proposals we wouldn't have gotten had it not been for our affiliation with CAES."

Mark Rudin, Ph.D.
President, Texas A&M Commerce
Former Vice President of Research and Economic Development, Boise State University and former CAES Steering Committee Member

University of Idaho Wins $700,000 IGEM Grant with CAES Support

The University of Idaho (UI) will work with food processors and suppliers in the Pacific Northwest to support reductions in their energy, water, and waste footprints as part of a new Idaho Global Entrepreneurial Mission (IGEM) grant awarded to UI and its partners around the state. The Idaho Department of Commerce recently released the first $700,000 installment of the $2.1 million grant earlier this month, with an additional $1.4 million in funding anticipated over the next two years. Professor Karen Humes, an expert in hydrology and geospatial science in UI's College of Science, will lead efforts to pilot, demonstrate, and transfer technologies that will help food processors and producers reduce water and nutrient use, as well as recycle nutrients and other valuable byproducts. Initial funding to develop the grant proposal was provided by CAES.

Students and faculty conduct research at the University of Idaho's Water Research Center in Boise.

CAES Hosts Five Major Working Meetings to Inform Strategy Development

Approaching its 10-year anniversary, CAES underwent a significant revision of its strategic plan during the fiscal year. To help inform the development of the new strategy, five large collaborative meetings were held. Of the meetings, three had a focus on research in nuclear energy, national security, and clean energy. Participants shared their capabilities and expertise, offering their wants, needs, and ideas for the future direction of CAES' success. The goal of each meeting was to share the vision of the major areas of research that will benefit from collaboration in the next 3 years. All five meetings were held to identify gaps and challenges that CAES could help resolve by leveraging shared assets from each of the CAES member organizations.

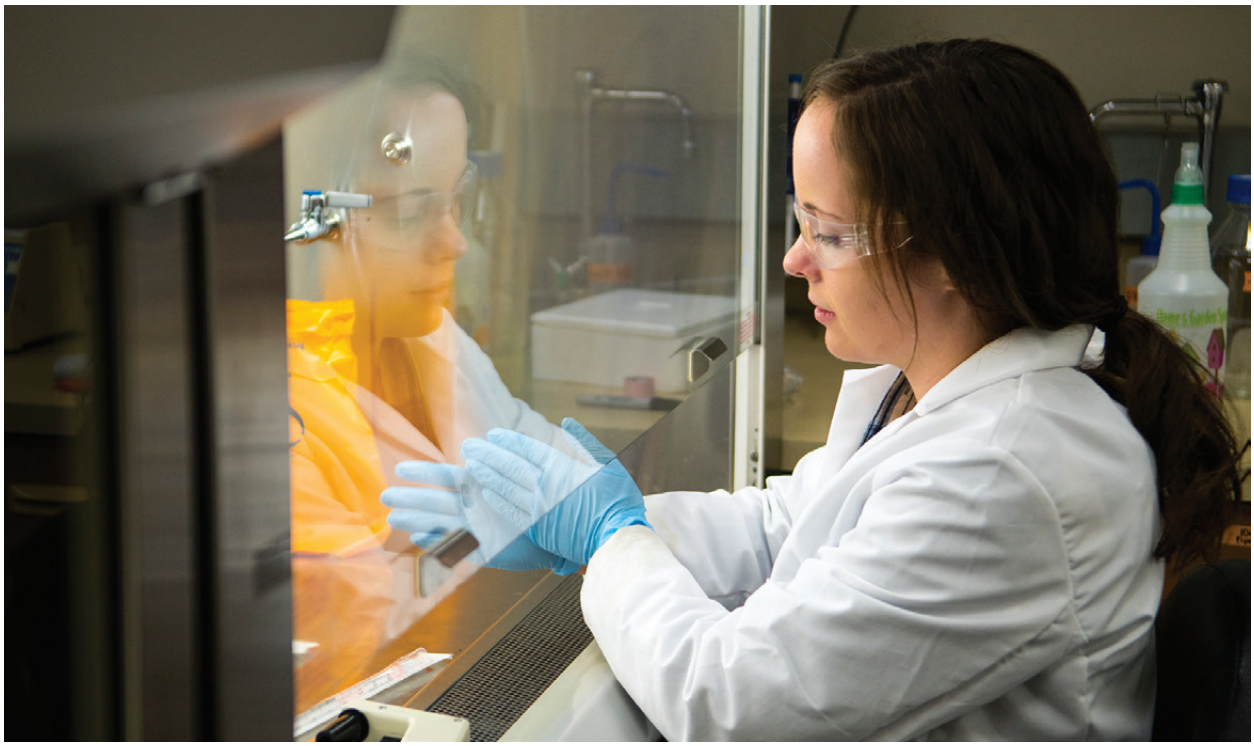
> Think of the earth as a perfect YETI cooler. It's an inherently good place to store heat, and we hope this research will take geothermal energy from a western boutique power source to a nationwide power source.

Travis McLing, Ph.D.
Laboratory Lead,
CAES Fluids Laboratory

CAES and Idaho Accelerator Center Host Isotope and Materials Working Meeting

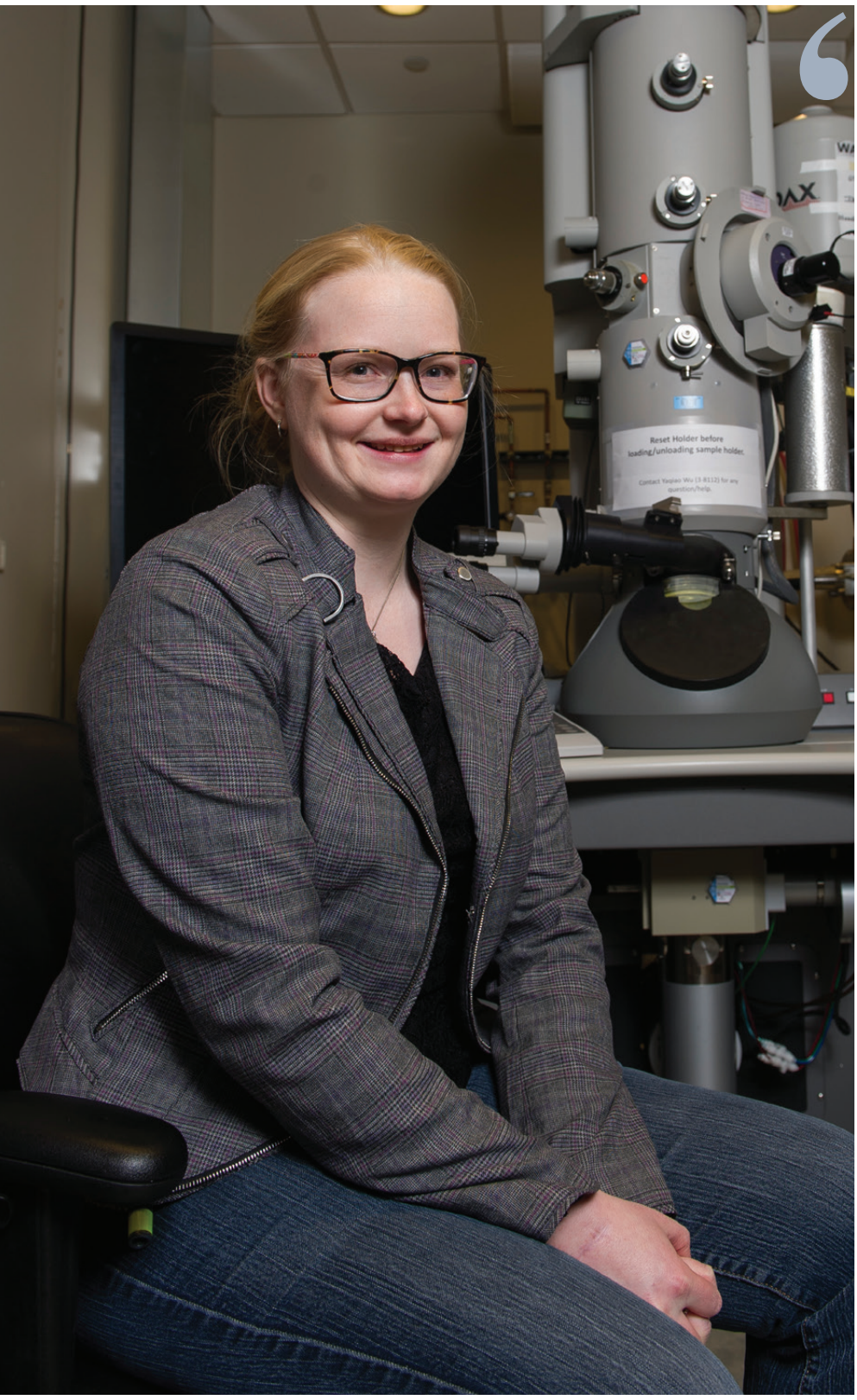
In June, CAES and Idaho State University (ISU) hosted a two-day working meeting in Idaho Falls aimed at forming a collaborative research initiative between CAES member institutions and the Idaho Accelerator Center (IAC). The working meeting began the process of creating dialogue between CAES entities, as well as development of a usage and capabilities road map for the center. It also answered questions about future facility needs for advancing isotope and nuclear materials science. Located in Pocatello, the IAC is a research facility operated by ISU featuring an array of electron accelerators for nuclear physics applications. A collaborative research planning meeting at CAES led to the discussion.

A researcher works inside a fume hood inside the Energy Innovation Laboratory.



CAES Hosts Molten Salt Working Meeting at University of Wyoming

CAES and the University of Wyoming held a collaborative working meeting in July focused on grid-scale energy storage systems. The purpose of the meeting was to discuss the current status, research gaps, CAES comparative advantage, and future prospects for grid-scale energy storage using molten salt systems. The meeting was attended by 32 individuals from Idaho National Laboratory, Boise State University, Idaho State University, the University of Idaho, the University of Wyoming, and Brigham Young University-Idaho. Collaboratively, the group developed a white paper outlining CAES capabilities in scientific, engineering, and economic drivers impacting molten salt energy storage. The group plans to continue meeting to develop a road map for a future federally funded research proposal that relates to molten salt energy-storage systems. The working meeting is the result of a collaborative research planning meeting that CAES held on clean energy.



> The materials challenge is the biggest one for advanced reactors. Ultimately, this research will help engineers understand how long a reactor can be run before adverse conditions in the cladding need to be addressed.

Elizabeth Getto, Ph.D.
CAES MaCS Lab customer
Assistant Professor,
U.S Naval Academy

CAES Energy Policy Research Conference Draws Sell-Out Crowd

CAES' Energy Policy Institute (EPI) hosted the eighth annual Energy Policy Research Conference at Boise State University in early September. Since 2011, the conference has brought researchers together from across the world to discuss a widerange of energy research topics including engineering, economics, law, political science, and other policy-relevant fields. A sellout crowd of more than 200 scholars, students, and practitioners from academia, industry, government, and nonprofits were on hand during this year's event. CAES Director Noël Bakhtian and CAES Fluids Laboratory Lead Travis McLing participated on an energy-water nexus panel session. The event was led by Kathleen Araújo, the new EPI director. Next year's conference will return to Boise Sept. 29–Oct. 1, 2019.

Participants at the 2018 CAES Energy Policy Research Conference in Boise.

Naval Academy First Military School to Use CAES MaCS Lab

In January, Elizabeth Getto, a mechanical engineering instructor at the U.S. Naval Academy, conducted research using tools inside the CAES Microscopy and Characterization Suite. Through the Department of Energy's Nuclear Science User Facilities program, Getto conducted a rapid turnaround experiment to study the effects of radiation and welding on oxide dispersion strengthened steels, commonly used in reactor vessels. The research represented the first time a U.S. military academy had taken advantage of the unique capabilities found in laboratory. Other institutions conducting microscopy work inside CAES this year include the University of Oxford, Purdue University, Texas A&M University, and the Massachusetts Institute of Technology.

University of Wyoming's Coddington Mentions CAES in Senate Testimony

Testifying before the U.S. Senate's Environment and Public Works Committee in November, the University of Wyoming's Kipp Coddington referenced his ongoing, collaborative relationship with CAES. Coddington, the director of the Carbon Management Institute at the School of Energy Resources, testified before the committee at a hearing titled "Promoting American Leadership in Reducing Air Emissions Through Innovation." During his testimony, Coddington outlined the numerous ways the university is examining methods to reduce carbon emissions through innovative technologies including research into carbon capture, utilization, and sequestration technologies. The Senate committee is chaired by Wyoming Sen. John Barrasso.

> Working at CAES has provided me access to remarkable people who took the time to talk with me about any topic of interest I brought to them.

Emma Redfoot
Fellow, OKLO Inc.
Former CAES Graduate Researcher

Idaho State University students examine samples inside a glovebox.

Working Meetings

In FY-18, CAES hosted several collaborative meetings.

Clean Energy Collaborative Research Planning Meeting – November 2017

Nuclear Energy Collaborative Research Planning Meeting – February 2018

National Security Collaborative Research Planning Meeting – February 2018

Education Collaborative Research Planning Meeting – March 2018

Industry Collaborative Research Planning Meeting – March 2018

Idaho Accelerator Center Roadmap Meeting – June 2018

Molten Salt Working Meeting – July 2018

Consolidated Innovation in Nuclear Research Joint Meeting – August 2018

Global Materials Working Meeting – August 2018

Energy Policy Research Conference – September 2018

Carbon Conversion Working Meeting – September 2018

Governor's LINE Commission Receives CAES Update

In May, the Leadership in Nuclear Energy (LINE) Commission 3.0 met in Arco for a quarterly briefing. During the meeting, the commission received an update from CAES Director Noël Bakhtian. This was the first time the commission had received a CAES briefing since 2012. During her presentation, Bakhtian provided an overview of the CAES mission and vision, spoke to the values CAES provides to the state, Idaho National Laboratory (INL), and the four member-universities. She also addressed operational activities including the hiring of a new leadership team and fiscal year plans to produce a refreshed multiyear strategic plan. The presentation concluded with a series of recent accomplishments and questions from commission members. Along with Bakhtian, additional members of the LINE Commission affiliated with CAES include INL's laboratory director and the three vice presidents for Research and Economic Development from Idaho's public research universities.

> At CAES, I have the opportunity to work with experts from diverse fields and areas of expertise. It can be challenging at times, but when you're able to help a researcher succeed, that's rewarding.

Kristi Moser-McIntire
CAES Safety Officer,
Idaho State University

CAES Hosts Materials Science Roadmap and Capabilities Meeting at Boise State University

CAES hosted a materials science road map and capabilities meeting in August. The event was the first in a series of gatherings at CAES member universities to enable INL scientists and university faculty the opportunity to meet and tour the unique capabilities in materials science and other research areas that exist on campus. During the two-day event, attendees received a detailed set of briefings on research and development work currently underway in the materials science field. Attendees also heard about the strategic directions of the university's materials science program. Approximately 60 people from INL and the four CAES member universities attended the event. The next capabilities meeting will be held at a different CAES member university.

ISU/CAES Assistant Professor Leslie Kerby, third from right, with her IEEE Brain Hackathon team.

ISU's Kerby Part of Winning Team at Big Data Competition in Japan

This summer, Idaho State University assistant professor Leslie Kerby and her team won the Institute of Electrical and Electronics Engineers (IEEE) Hackathon on Big Data Governance and Metadata and Management. The event, held in Tokyo, challenged teams to develop a data mashup scheme to cross reference datasets and apply statistical analysis, machine learning, and visualization tools to analyze and develop predictive models. Kerby's team included Frederic Andres, with the National Institute of Informatics in Tokyo, and Joey Costoya, senior researcher at Trend Micro Incorporated at National Capital Region, Philippines. The competition took place during the IEEE's 42nd International Conference on Computers, Software, and Applications, which explored the evolving relationship between humans and autonomous technology.

CAES Hosts Carbon Conversion Working Meeting in Idaho Falls

A Carbon Conversion working meeting was hosted in September at CAES' Idaho Falls headquarters facility. The event brought together research and technical collaborators from Idaho National Laboratory, the University of Wyoming, Idaho State University, and the University of Idaho. During the event, participants presented information on university and laboratory capabilities, and discussed opportunities for joint proposals and federal grants in the areas of carbon capture, sequestration, and conversion. The event was a follow-up to a related meeting held last year at the University of Wyoming campus.

FY2018 NUCLEAR ENERGY UNIVERSITY PROGRAM (NEUP) PRIME AWARDS

NEUP R&D AWARD	$640,000	DR. VIVEK UTGIKAR (UI)	DEVELOPMENT OF NUCLEAR HYBRID ENERGY SYSTEMS: TEMPERATURE AMPLIFICATION THROUGH CHEMICAL HEAT PUMPS FOR INDUSTRIAL APPLICATIONS
NEUP R&D AWARD	$574,638	DR. VIVEK UTGIKAR (UI)	NOVEL PROCESSES FOR CAPTURE OF RADIOACTIVE IODINE SPECIES FROM VESSEL OFF-GAS STREAMS
NEET AWARD	$830,000	DR. VIVEK AGARWAL (INL)	ANALYTICS-AT-SCALE OF SENSOR DATA FOR DIGITAL MONITORING IN NUCLEAR PLANTS
NEUP R&D AWARD	$800,000	DR. INDRAJIT CHARIT (UI)	FRICTION-STIR-BASED REPAIR WELDING OF DRY STORAGE CANISTERS AND MITIGATION STRATEGIES: EFFECT OF ENGINEERED BARRIER LAYER ON ENVIRONMENTAL DEGRADATION
NEUP R&D AWARD	$611,640	DR. RICH CHRISTENSEN (UI)	MODELING AND EXPERIMENTAL VERIFICATION OF THERMAL ENERGY STORAGE SYSTEMS TO ENABLE LOAD-FOLLOWING CAPABILITY FOR NUCLEAR REACTORS

FY2018 NUCLEAR ENERGY UNIVERSITY PROGRAM (NEUP) PARTNER AWARDS

NEUP R&D AWARD	$169,000	DR. VIVEK UTGIKAR(UI), DR. PIYUSH SABHARWALL (INL)	DEVELOPMENT OF NUCLEAR HYBRID ENERGY SYSTEMS: TEMPERATURE AMPLIFICATION THROUGH CHEMICAL HEAT PUMPS FOR INDUSTRIAL APPLICATIONS
NEUP R&D AWARD	$225,362	DR. VIVEK UTGIKAR (UI), DR. KRISHNAN RAJA (INL), DR. PIYUSH SABHARWALL (INL)	NOVEL PROCESSES FOR CAPTURE OF RADIOACTIVE IODINE SPECIES FROM VESSEL OFF-GAS STREAMS
NEUP R&D	$150,000	DR. RICH CHRISTENSEN (UI), DR. PIYUSH SABHARWALL (INL)	MODELING AND EXPERIMENTAL VERIFICATION OF THERMAL ENERGY STORAGE SYSTEMS TO ENABLE LOAD-FOLLOWING CAPABILITY FOR NUCLEAR REACTORS
NEET AWARD	$170,000	DR. VIVEK AGARWAL (UI), DR. AHMAD AL RASHDAN (INL), DR. RON BORING (INL)	ANALYTICS AT SCALE OF SENSOR DATA FOR DIGITAL MONITORING IN NUCLEAR PLANTS

FY2018 LABORATORY DIRECTED RESEARCH AND DEVELOPMENT (LDRD) PRIME AWARDS

$430,185	DR. MAOHONG FAN (UW), DR. DONG DING (INL)	DEVELOPMENT OF DIRECT CARBON FUEL CELLS
$258,017	DR. BRIAN JAQUES (BSU), DR. CHAO JIANG (INL)	MICROSCALE TECHNIQUE TO EVALUATE GRAIN BOUNDARY COHESION OF IRRADIATED ALLOYS

FY2018 LABORATORY DIRECTED RESEARCH AND DEVELOPMENT (LDRD) PARTNER AWARDS

$160,699	DR. BRIAN JOHNSON (UI), DR. MICHAEL HANEY (UI), PHILLIP RICHARDSON (UI), DR. CRAIG RIEGER (INL)	RESILIENT, SCALABLE CYBER STATE AWARENESS OF INDUSTRIAL CONTROL SYSTEM NETWORKS TO THREAT
$95,347	DR. HAIYAN ZHAO (UI), DR. JEREMIAH DUSTIN (UI), DR. JIEUN LEE (UI) DR. SHELLY LI (INL)	INVESTIGATION OF SONICATION-ASSISTED ELECTROLYTIC REDUCTION OF USED OXIDE FUEL IN MOLTEN SALT
$431,918	DR. MICHAEL GLAZOFF (UI), DR. DONGMEI (KATIE) LI (UW), DR. SHUAI TAN (UW), DR. REBECCA FUSHIMI (INL)	TAILORING THE KINETIC FUNCTION OF A SURFACE THROUGH ELECTRONIC EFFECTS OF NANOSCALE ARCHITECTURE
$114,961	SAM GIEGEL (ISU), DR. CHAD POPE (ISU), DR. GEORGE IMEL (ISU), DR. AARON CRAFT (INL)	CHARACTERIZATION OF NEUTRON BEAMLINES AT NEUTRON RADIOGRAPHY REACTOR
$316,328	DR. HAIYAN ZHAO (UI), DR. LUKE WILLIAMS (INL)	ADVANCED CARBON-FEEDSTOCK PROCESSING USING IONIC LIQUIDS
$222,180	DR. VIVEK UTGIKAR (UI), DR. JARED PERKO (BSU), KEVIN LYON (INL)	MODELING AND SIMULATION FOR NUCLEAR FUEL-CYCLE SEPARATIONS USING MODULAR COUPLING
$255,641	BRANDON DAY (UI), DR. DONNA BAEK (INL)	ELECTRO-REDUCTION OF METALS IN SUPERCRITICAL-FLUID ROOM-TEMPERATURE IONIC LIQUIDS
$258,017	DR. RAY FERTIG (UW), DR. INDRAJIT CHARIT (UI), DR. CHAO JIANG (INL)	MICROSCALE TECHNIQUE TO EVALUATE GRAIN BOUNDARY COHESION OF IRRADIATED ALLOYS
$271,913	DR. RICHARD CHRISTENSEN (UI), DR. COLBY B. JENSEN (INL)	IN-PILE INVESTIGATION OF TRANSIENT BOILING IN TREAT
$248,127	DR. HAROLD BLACKMAN (BSU), DR. RON BORING (INL)	HUMAN RELIABILITY ANALYSIS FOR ADVANCED-REACTOR TECHNOLOGIES AND SYSTEMS
$277,887	DR. ERIC JANKOWSKI (BSU), DR. MATTHEW JONES (BSU), MIKE HENRY (BSU), BRYTON ANDERSON (BSU), DR. KEVIN GERING	SURFACE MORPHOLOGICAL PATTERNING, STRUCTURE-ACTIVITY MODELING, AND AGING ANALYSIS OF CATALYST MATERIALS TO ENHANCE ODH-REACTION CONVERSION EFFICIENCY AND IMPROVE CATALYST LIFETIME
$245,319	RYAN CARNAHAN (ISU), DR. CHENG SUN (INL)	ADVANCED MANUFACTURING OF FUEL-CLADDING MATERIALS BY EQUAL-CHANNEL ANGULAR PRESSING
$104,972	DR. KUMARI SHARMA (ISU), DR. CHRISTOPHER ZARZANA (INL)	SOLVENT RADIOLYSIS-PRODUCT PRODUCTION USING PREPARATIVE HPLC

> CAES has been a fantastic experience. I was able to connect with people in industry that I wouldn't have had access to before. Working here is how I got my internship, how I got connected to the lab system, and a big part of how I was able to receive my fellowship.

Seth Dustin
Fellow, Los Alamos National Laboratory
Former CAES Graduate Researcher

EDUCATION HIGHLIGHTS

CAES First Annual Summer Visiting Faculty Program Begins

CAES launched its first annual Summer Visiting Faculty program in June. The program works to foster interaction and networking between university faculty and Idaho National Laboratory (INL) researchers with the goal of developing a joint-funded research proposal of value to both parties.

The program allows each faculty member and INL researcher to spend a week at CAES headquarters outlining their research proposal. Then, the pair continues to collaborate throughout the summer. Participants provide a presentation on their proposal at CAES in August before submitting it for funding. The CAES Summer Visiting Faculty program was developed following a series of collaborative planning meetings held earlier this fiscal year between the CAES member universities and INL.

During the inaugural year, CAES provided a part-time summer salary and travel for six faculty members from CAES member universities. The three research areas selected for this year's program included nuclear energy, cybersecurity, and energy-water nexus.

Faculty members and INL researchers participating in the inaugural program included:

Nuclear Energy

- Mike Hurley (Boise State University) worked with Gabriel Ilevbare
- David Arcilesi (University of Idaho) worked with Donna Guillen
- Mike McKellar (University of Idaho) worked with Donna Guillen

Cybersecurity

- Dakota Roberson (University of Idaho) worked with Steve Hartenstein and Wayne Austad
- Michael Haney (University of Idaho) worked with Steve Hartenstein and Wayne Austad

Energy-Water Nexus

- Jon Brant (University of Wyoming) worked with Travis McLing

CAES Launches Seminar Series Featuring University, Laboratory, and Industry Leaders

A monthly seminar series focused on collaboration and problem-solving was launched at CAES in March. The brainchild of the University of Idaho's Dakota Roberson, the CODEBREAKER seminar series features talks by students, university faculty, Idaho National Laboratory researchers, and outside guests from academia and industry. Each 90-minute session includes a technical or informative lecture on a CAES research or focus area. Presenters also answer audience questions and seek collaborative opportunities for joint proposals or research development. The seminars are broadcast online for those who can't attend in person.

FY-18 CAES Seminar Series Speakers

March **Dakota Roberson** – University of Idaho
Stability of the Western North American Electric Grid

April **Travis McLing** – Idaho National Laboratory
The Water-Food-Energy Nexus

May **Michel Haney** – University of Idaho
Bitcoin, Litecoin, and the Future Economy

June **James Money** – Idaho National Laboratory
The Future of Real-time 3D Visualization

July **Emma Redfoot** – University of Idaho
Nuclear Renewable Hybrid Energy Systems

Aug. **Nicolas Lee** – Stanford University
Space Energy Harvesting and Wireless Power-transfer Concepts

Sept. **John Kotek** – Nuclear Energy Institute
The Future of Nuclear Energy in the U.S.

> Over the years, Wyoming researchers have benefited from a variety of regional relationships from Idaho National Laboratory, including the Center for Advanced Energy Studies.

Kipp Coddington
University of Wyoming,
U.S. Senate Testimony
Nov. 2017

CAES Supports *My Amazing Future* with Interactive Events, Guest Speakers

The 2018 *My Amazing Future* event, which brought together 150 eighth-grade girls from four school districts to learn about science, technology, education, and math (STEM) careers, was held at INL and CAES in March. During the event, students performed dozens of hands-on science experiments, listened to laboratory researchers address career and education opportunities, and toured laboratory facilities. At CAES, several facilities and labs were temporarily turned into interactive learning spaces. CAES staff and students—including Donna Wuthrich, James Money, Tammie Borders, Leslie Kerby, Ross Kunz, Meng Shi, Eugene Engmann, Emma Redfoot, Charles Elverson, Derek Stucki, and Jieun Lee—ushered students through a series of activities and events involving advanced visualization, robotics, and renewable energy. CAES Director Noël Bakhtian provided closing remarks to the students.

Students participate in the 2018 My Amazing Future event at CAES.

Wyoming Women of Influence Conference Hosts CAES Director for Motivational Talk

During the 6th annual Wyoming Women of Influence awards ceremony in Cheyenne in August, CAES Director Noël Bakhtian delivered the keynote address. Nearly 400 people gathered at the event to honor 10 women from across Wyoming for their outstanding work in business, achievement, and mentorship. As an invited guest, Bakhtian spoke about ways to make women visible in work environments traditionally dominated by men. She also addressed her personal education pathway that led to degrees from Duke, Cambridge, and Stanford University. In addition, she shared her curiosity for science and engineering, and how it led to career opportunities with NASA, the Department of Energy, the White House, and now CAES. The event was sponsored by the Wyoming Business Report and the University of Wyoming, a CAES member university.

CAES Director Keynotes Idaho Conference on Undergraduate Research

CAES Director Noël Bakhtian provided the keynote address at the July 2018 Idaho Conference on Undergraduate Research at Boise State University. The event is the state's premier annual conference for undergraduate students working on degrees in STEM-focused areas. During the keynote, Bakhtian spoke to an estimated 200 students about her education and career path, including her research opportunities at the National Aeronautics and Space Administration, the U.S. Department of Energy, and the White House's Office of Science and Technology Policy.

"National laboratories and universities have strong research and education cultures that lead to critical innovations and technological advancements. We see tremendous opportunity to link our strengths more closely with private sector research and work-force needs."

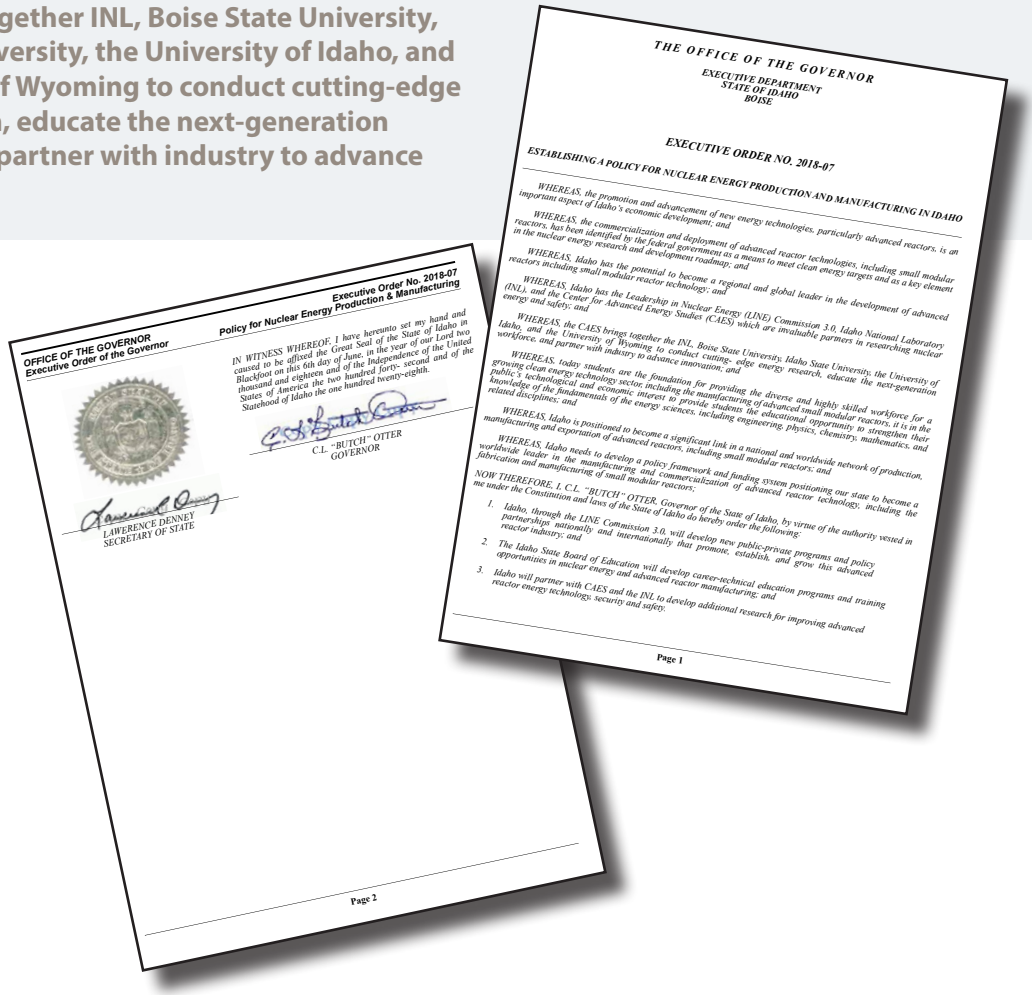
Leah Guzowski
Director,
CAES and INL Industry
Research and Development

INNOVATION HIGHLIGHTS

Idaho Governor Signs Nuclear Energy Executive Order Highlighting CAES

In early June, Idaho Gov. C.L. "Butch" Otter signed Executive Order 2018-07, establishing a policy for nuclear energy manufacturing and production in Idaho. The order calls on the state of Idaho to partner with CAES and INL to develop research for improving advanced reactor energy technology, security, and safety. Specifically, it asks the LINE Commission 3.0 to develop new public-private programs and policy partnerships nationally and internationally. These will promote, establish, and grow the advanced nuclear reactor industry. It also directs the Idaho State Board of Education to develop career and technical education programs and training opportunities in nuclear energy and advanced-reactor manufacturing.

"CAES brings together INL, Boise State University, Idaho State University, the University of Idaho, and the University of Wyoming to conduct cutting-edge energy research, educate the next-generation workforce, and partner with industry to advance innovation."



THE OFFICE OF THE GOVERNOR
EXECUTIVE DEPARTMENT
STATE OF IDAHO
BOISE

EXECUTIVE ORDER NO. 2018-07

ESTABLISHING A POLICY FOR NUCLEAR ENERGY PRODUCTION AND MANUFACTURING IN IDAHO

WHEREAS, the promotion and advancement of new energy technologies, particularly advanced reactors, is an important aspect of Idaho's economic development; and

WHEREAS, the commercialization and deployment of advanced reactor technologies, including small modular reactors, has been identified by the federal government as a means to meet clean energy targets and as a key element in the nuclear energy research and development roadmap; and

WHEREAS, Idaho has the potential to become a regional and global leader in the development of advanced reactors including small modular reactor technology; and

WHEREAS, Idaho has the Leadership in Nuclear Energy (LINE) Commission 3.0, Idaho National Laboratory (INL), and the Center for Advanced Energy Studies (CAES) which are invaluable partners in researching nuclear energy and safety; and

WHEREAS, the CAES brings together the INL, Boise State University, Idaho State University, the University of Idaho, and the University of Wyoming to conduct cutting- edge energy research, educate the next-generation workforce, and partner with industry to advance innovation; and

WHEREAS, today students are the foundation for providing the diverse and highly skilled workforce for a growing clean energy technology sector, including the manufacturing of advanced small modular reactors; it is in the public's technological and economic interest to provide students the educational opportunity to strengthen their knowledge of the fundamentals of the energy sciences, including engineering, physics, chemistry, mathematics, and related disciplines; and

WHEREAS, Idaho is positioned to become a significant link in a national and worldwide network of production, manufacturing and exportation of advanced reactors, including small modular reactors; and

WHEREAS, Idaho needs to develop a policy framework and funding system positioning our state to become a worldwide leader in the manufacturing and commercialization of advanced reactor technology, including the fabrication and manufacturing of small modular reactors;

NOW THEREFORE, I, C.L. "BUTCH" OTTER, Governor of the State of Idaho, by virtue of the authority vested in me under the Constitution and laws of the State of Idaho do hereby order the following:

1. Idaho, through the LINE Commission 3.0, will develop new public-private programs and policy partnerships nationally and internationally that promote, establish, and grow this advanced reactor industry; and
2. The Idaho State Board of Education will develop career-technical education programs and training opportunities in nuclear energy and advanced reactor manufacturing; and
3. Idaho will partner with CAES and the INL to develop additional research for improving advanced reactor energy technology, security and safety.

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OFFICE OF THE GOVERNOR
Executive Order of the Governor

Executive Order No. 2018-07
Policy for Nuclear Energy Production & Manufacturing

IN WITNESS WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Idaho in Blackfoot on this 5th day of June, in the year of our Lord two thousand and eighteen and of the Independence of the United States of America the two hundred forty- second and of the Statehood of Idaho the one hundred twenty-eighth.

C.L. "BUTCH" OTTER
GOVERNOR

LAWERENCE DENNEY
SECRETARY OF STATE

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> The value of CAES comes in the opportunity to perform collaborative research. It's easy to walk 100 feet to talk with a researcher from another university who's just down the hall. It's harder to do that when they work on the other side of the state.

Bob Borelli, Ph.D.
Assistant Professor,
Nuclear Engineering
University of Idaho

CAES Hosts Idaho Industries Breakfast, Meets with Congressional Delegations

Several members of the CAES leadership team traveled to Washington, D.C., in June to host the Idaho Industries Breakfast and hold meetings on Capitol Hill with federal elected officials from Idaho and Wyoming. During the industry breakfast, CAES Director Noël Bakhtian updated the 80-plus attendees on the CAES mission, vision, strategy development, and recent accomplishments. Later in the day, the team met individually with Idaho Senators Mike Crapo and Jim Risch and Congressman Mike Simpson. The team also met with staff members from Congressman Raúl Labrador's office. Similarly, the group met with Wyoming Sen. John Barrasso and staff from Sen. Mike Enzi's office.

A Boise State University student explores computer-generated imagery through a set of Oculus Rift 3D goggles.

BY THE NUMBERS

Through collaboration, CAES member organizations leverage the following collective assets:

8,000 More than 8,000 scientists, engineers, faculty, and support staff

63,000 More than 63,000 students

1,100 More than 1,100 degrees and certificates offered

100 Nearly 100 laboratories and engineering facilities

$1.8B Approximately $1.8 billion in annual research funding

Investments

$7.1M $7.1 million Idaho National Laboratory investments in CAES

$3M State of Idaho investments in CAES

Outreach

1,669
Visitors to CAES and the CAVE 3D immersive research environment

48
Working meetings, seminars, and speeches hosted or sponsored by CAES

343
CAES publications and proceedings

Research and Program Funding

$3,456,278 Federal nuclear energy funding awarded to CAES member faculty members (primary award)

$705,362 Federal nuclear energy funding awarded to CAES member faculty members (secondary award)

$688,212 Laboratory Directed Research and Development funding (primary award)

$4,000,000 Laboratory Directed Research and Development projects (secondary award)

$878,465 Program-development funding awarded to CAES member organizations for 30 strategic research projects.

University Impact at INL

NINETY-TWO
students from CAES member universities interned at Idaho National Laboratory

SEVENTEEN
faculty members from CAES member universities were awarded joint appointments at Idaho National Laboratory

9 students from CAES member universities were offered graduate fellowships at Idaho National Laboratory

6 faculty from CAES member universities participated in the inaugural Visiting Summer Faculty program

5 students from CAES member universities were awarded postdoctoral appointments at Idaho National Laboratory

RESEARCHER, FACULTY, STAFF, AND STUDENT ACCOMPLISHMENTS

CAES Graduate Researcher Earns Fellowship at Los Alamos National Laboratory

This summer, CAES graduate researcher Seth Dustin earned a research fellowship at Los Alamos National Laboratory. As a student at CAES, Dustin worked alongside Idaho National Laboratory researchers Prabhat Tripathy and Michael Shaltry on a project for the Critical Materials Institute involving electrochemical measurements of rare-earth materials in molten salt.

CAES Graduate Student Earns Industry Fellowship at Oklo, Inc.

CAES graduate student Emma Redfoot earned a six-month fellowship at microreactor startup Oklo, Inc. The company is designing a small, portable nuclear reactor that is waste and carbon negative. Based in Sunnyvale, CA, the company was founded in 2013 and is working to develop a 2-megawatt compact fast reactor to bring distributed, clean, affordable, and reliable nuclear power to the market. During her time at CAES, Redfoot also defended her master's thesis, "Allocating Heat and Electricity in a Nuclear Renewable Hybrid Energy System Coupled with a Water Purification System."

The Materials Society Awards Best Poster to CAES Student

During the 2018 Minerals, Metals, & Materials Society's annual meeting, CAES graduate researcher Meng Shi was awarded best student research poster for her work on Electrolytic Reduction on TiO2 in Molten Li2O/LiCl. Her research project used an electrochemical method to reduce metal oxide in spent nuclear fuel to a lower oxidative status. She found that by controlling parameters, like cathodic potentials, the carbon efficiency can reach 17 percent with a possible reduction extent up to 25 percent.

Four CAES University Students Part of INL's 2018 Graduate Fellows Program

Idaho National Laboratory welcomed 13 students into the second cohort of the Graduate Fellows program, four of whom came from CAES member universities. The program integrates students into the national laboratory and allows them to contribute to significant research projects that will help them fulfill their thesis research requirements. The laboratory gains access to skilled staff, along with the opportunity to build long-term collaborations with universities, increase recruiting opportunities, and interact with a continuous pipeline of students interning and conducting research at the lab. Both the universities and INL have the opportunity for joint publications and intellectual property. Fellows from CAES member universities include Corey Michael Efaw, Sohel Rana, and Jennifer Kay Watkins from Boise State University, and Emerald Dawn Ryan from Idaho State University.

CAES Intern from Idaho State University Supports LINE Commission Study

Idaho State University Career Path Intern Pedro Mena, working alongside ISU's Leslie Kerby, supported a research study evaluating the value chain for advanced reactors, specifically as it pertains to opportunities for the state of Idaho. The study was coordinated with the Idaho Leaderhip in Nuclear Energy Commission to inform state leaders about the market potential, value propositions, types of energy sector markets (e.g., utilities, industry, transportation), mechanisms to attract advanced-reactor manufacturers, and the potential for the development of a reactor-manufacturing industry in the state.

CAES would like to congratulate the following students from CAES member universities working as graduate assistants or supporting our research in a range of subjects including nuclear engineering, physics, and chemistry. The following students defended their master's thesis or doctoral dissertation:

University of Idaho
- WaiLam Chan
- Stephen Hancock
- Jieun Lee
- Emma Redfoot
- Amey Shirekar

Boise State University (doctoral students)
- Steven LeTourneau
- Kassi Smith

Idaho State University
- Shawn Fredstrom
- Nathaniel Gardner
- Brittany Grayson
- Connor Harper
- Mason Jaussi
- Daniel Sluder
- Aaron Thompson
- Kory Walling

Christensen Named University of Idaho's College of Engineering's Outstanding Faculty Member of the Year

In May, CAES Associate Director Rich Christensen was named the University of Idaho (UI) College of Engineering's outstanding faculty member of the year. Following selection by an executive committee of peers, the annual award was given to a faculty member who serves as a role model and helps shape the college's high standard of achievement through their hard work and dedication to engineering. Christensen, who joined the university in 2015, is an internationally recognized scholar and leader in a wide range of nuclear and thermal science research areas. Prior to his time at UI, Christensen had a distinguished 37-year career at The Ohio State University, where he achieved professor emeritus status.

Jaussi Completes Master's Degree, Earns Radiation Safety Officer Certification

Mason Jaussi, CAES Health Physicist, received his master's degree this year from Idaho State University, and is now a certified radiation safety officer. He completed his thesis, "Developing Am-DTPA (Americium-Diethylenetriamine pentaacetate) and Biokinetic Model," based on chelation treatments to model Am-DTPA to excrete radiation and determine dosage for the human body. Jaussi is currently working on his Certified Health Professional Certificate, gaining operational experience, and training on radiological materials.

Business Insider Names CAES Director One of 2018's Top Female Engineers

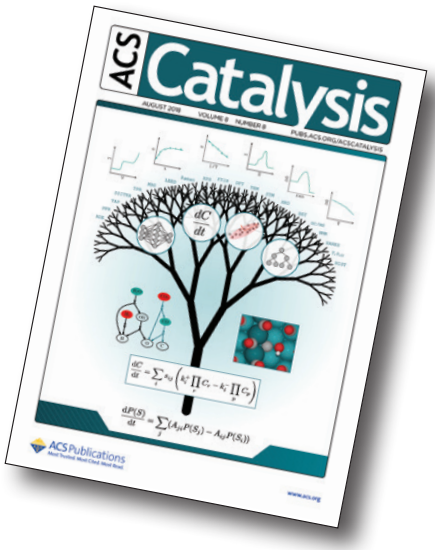
In honor of International Women in Engineering Day, *Business Insider* published a list of the 39 most powerful female engineers of the year. CAES Director Noël Bakhtian came in as No. 11 on the most powerful list. *Business Insider* is one of the most widely read business and technology websites in the world with more than 80 million monthly visitors. In naming each awardee, the editors noted that despite the "arm waving about a lack of female STEM professionals…these are women with engineering backgrounds who are running big business units at important companies, are building impressive up-and-coming technologies, or acting as leaders and role models in the tech communities."

Kunz Receives Doctoral Degree in Statistics from Idaho State University

Idaho National Laboratory employee Ross Kunz received his doctoral degree in statistics this year. His dissertation, "Fused Lasso and Tensor Covariance Learning with Robust Estimation," touched on block structure for estimation using sets of information to explain an event. Kunz, a data scientist in INL's High Performance Computing and Data Analytics department, looked at relationships between gas species of the overall catalytic process rather than physics just using data. Kunz plans to continue his work supporting Dr. Rebecca Fushimi's research in catalysis and transient kinetics.

CAES Researcher Named to INL's Inventors Hall of Fame

During the INL Laboratory Director Awards ceremony in April, CAES researcher Harry Rollins was inducted into the laboratory's Inventors Hall of Fame. Rollins, who supports research and engineering efforts in the CAES Catalysis and Transient Kinetics Laboratory, was honored for being issued five career patents. As an INL principal investigator, his areas of research include synthesis and characterization of novel phosphorous-nitrogen compounds as advanced electrolytes for lithium-ion batteries, preparation and characterization of nanoscale catalysts for the production of synthetic fuels, and preparation of nanomaterials using supercritical fluid technology and nanomaterials characterization. Rollins holds a doctorate in analytical chemistry from Clemson University.



The cover of the August 2018 issue of Catalysis Magazine *features a graphic on multiple ways to analyze catalysis data. The cover resulted from a project that took place inside the CAES Catalysis and Transient Kinetics Laboratory.*

McLing Speaks on Water Security at National Governors Association Conference

In September, the National Governors Association's Center for Best Practices hosted the 2018 Annual Water Policy Institute which brought together water specialists from 31 states along with outside experts to talk about pressing issues surrounding water security. During the event, CAES researcher Travis McLing led a panel discussion on water security with an emphasis on cybersecurity. The panel featured notable experts from across the country speaking on topics ranging from infrastructure hardening to vulnerability assessments. In addition to his role as laboratory lead, McLing is the program manager for Idaho National Laboratory's Water Security Test Bed.

NEW HIRES

Kathleen Araújo
In July, Kathleen Araújo was hired as the director of the CAES Energy Policy Institute. The institute is located on the Boise State University campus and focuses on strategic problem-solving and opportunities in energy through a crosscutting, socio-technical approach that informs policy makers, communities, and private industry. Araújo earned her doctorate at the Massachusetts Institute of Technology, completing postdoctoral research at the Harvard Kennedy School on science, technology and public policy, and nuclear safety. She has worked as an assistant professor of energy-environmental innovation systems and policy at Stony Brook University, and as a researcher with Brookhaven National Laboratory, where she worked in the divisions for nuclear nonproliferation and national security, and sustainable energy. In addition, she is a book-series editor for Routledge's studies in Energy Transitions.

Leah Guzowski
In September, Leah Guzowski was hired as the director of Industry Research and Development for CAES. She also serves as Idaho National Laboratory's director of Industry Engagement in a concurrent role. She comes to CAES from Argonne National Laboratory, where she served as commercial team lead for the U.S. Department of Energy, Building Technology Program. Guzowski's previous work includes strategic consulting and business development for clean technology companies and macro-level economic analysis research for international governments. She is a graduate of Harvard University and the University of Wisconsin-Madison. She also studied economics and policy at the University of Oxford.

Jana Pfeiffer
In May, Jana Pfeiffer joined CAES as the research operations lead. In this role, Pfeiffer supports day-to-day technical, safety, facility, and operational activities for laboratories, equipment, and research operations to ensure successful execution of the CAES mission and vision. She is also the first point of contact for Idaho National Laboratory researchers who want to perform laboratory work at CAES. She provides direction on how to initiate the CAES processes for INL off-site work. Her extensive experience conducting hands-on research in both laboratory and radiological environments adds exceptional operational support to the CAES team. She holds a bachelor's degree in chemistry from Idaho State University.

Jeff Benson
In February, Jeff Benson was hired as the CAES business operations lead. He is responsible for coordination of business outcomes, project management, and CAES process improvement. Prior to joining CAES, Benson worked for the Nuclear Science User Facilities at Idaho National Laboratory as a program administrator. He holds a master's degree in public administration from Marriott School of Management at Brigham Young University and a bachelor's degree in education from Brigham Young University.

PUBLICATIONS AND PROCEEDINGS

In fiscal year 2018, CAES member organizations published 343 papers, journal articles, reports, and conference proceedings. The following pages include an alphabetized list of the CAES publications and proceedings for fiscal year 2018 as reported by each organization's associate director.

Boise State University

1. Aldrich, L., & Koerner, C. (2018). Challenges to trading white certificates. *The Electricity Journal. 31*(4), 41-47.
2. Aldrich, L., & Koerner, C. (2018). White certificates: market status and trends. *The Electricity Journal. 31*(3), 52-63.
3. Aldrich, L., & Koerner, C. White certificate trading: A dying concept or just making its debut? Part II: Challenges to trading white certificates, The Electricity Journal, Volume 31, Issue 4, 2018, Pages 41-47, ISSN 1040-6190, https://doi.org/10.1016/j.tej.2018.05.006.
4. Baatz, R., Sullivan, P. L., Li, L., Weintraub, S., Loescher, H. W., Mirtl, M.,...Van Looy, K. (2018). Integration of terrestrial observational networks: opportunity for advancing Earth system dynamics modelling. *Earth System Dynamics, 9,* 593-609. https://doi.org/10.5194/esd-9-593-2018.
5. Barnes, P., Savva, A., Dixon K., Bull H., Rill, L., Karsann, D.,…Xiong, H. * (2018). Electropolishing valve metals with a sulfuric acid-methanol electrolyte at low temperature. *Surface & Coatings Technology, 347,* 150–156.
6. Bateman, A., Queale, A.J., Butt, D.P., & Jaques, B.J. (2018). Effects of sintering aids on the hydrothermal oxidation of silicon nitride spherical rolling elements. *Corrosion Engineering, Science and Technology*. DOI: 10.1080/1478422x.2018.1523290.
7. Blackman, H. S., & Boring, R. (2017). Assessing dependency in SPAR-H: some practical considerations. In R. Boring (Ed.), *Advances in Human Error, Reliability Resilience, and Performance (Advances in Intelligent Systems and Computing).* Heidelberg: Springer Verlag.
8. Burns, J., Wu, Y., & Taylor, J. (2018, June). The application of an X-ray diffraction to nuclear materials at MaCS, CAES [Powerpoint slides]. Presented at the Isotope and Materials Science Roadmapping Workshop, Idaho Falls, ID.
9. Dangol N., Shrestha,D.S., & Duffield, J. (2017). Life-cycle energy, GHG and cost comparison of camelina-based biodiesel and biojet fuel. *Biofuels,* 1-9. DOI: 10.1080/17597269.2017.1369632.
10. Dunkel C., Shrestha D., Beyerlein S. (2017). *Feasibility and economic analysis for creating a viable cogeneration design for the campus wood-fired boiler.* Paper No. 171201 presented at the meeting of the American Society of Agricultural and Biological Engineers, St. Joseph, MI.
11. Estrada, D. (2017, November). *Aerosol jet printing of flexible electronics*. Paper presented at the 9th Annual International Optomec Users Meeting, Santa Clara, CA.
12. Forsmann, B., Wu, Y., & Burns, J. (2018, June). Center for Advanced Energy Studies Advanced Materials Laboratory radiological capabilities [Powerpoint slides]. Presented at the Isotope and Materials Science Roadmapping Workshop, Idaho Falls, ID.
13. Fowler, L. & Johnson, A. (2017). Overlapping authorities in U.S. energy policy. *The Electricity Journal 30*(9), 1-5.
14. Fujimoto, K., Davis, K., Tsai, K., Watkins, J., Unruh, T., & Estrada, D. (2017, November). *Aerosol jet printing of in-pile nuclear sensors*. Paper presented at the 9th Annual International Optomec Users Meeting, Santa Clara, CA.
15. Fujimoto, K., Unruh, T., Watkins, J., Subbaraman, H., & Estrada, D. (2018, April). *Additive manufacturing of in – pile nuclear sensors.* Poster session presented at the NASA In-Space Manufacturing and Printed Electronics Workshop, Huntsville, AL.
16. Gates, G., Butt, D., Burns, J., Wu, Y., Alanko, G., & Watkins, J.K. (2018, August). *The internal morphology and composition of a purple pigment particle extracted from an ancient Faiyum mummy portrait.* Paper presented at M&M 2018, Baltimore, MD.
17. Godwin†, L., Brown†, D., Livingston, R., Webb, T., Karriem, L., Graugnard, E., & Estrada, D. Open source, automated chemical vapor deposition system for production of two-dimensional nanomaterials, *PLOS One*, in review.
18. Henry, M., Miller, E., Jones, M. & Thomas, S. (2018, March). Poster session presented at the meeting of the American Physical Society, Los Angeles, CA.
19. Hollar, C., Varghese, T., Kongara, M., Lin, Z., Duan, X., Estrada, D., & Zhang, Y. (2018, April). *High-performance flexible thermoelectric thin films from solution processed colloidal nanoplates.* Poster session presented at the NASA In-Space Manufacturing and Printed Electronics Workshop, Huntsville, AL.
20. Hondros, M., Tuft, S., Karriem, L., Pandhi, T., Chandnani, A., Convertino, D.,… Estrada, D. (2018, April). *Differential gene expression in C2C12 cells due to scaffold structure-property-processing correlations.* Poster session presented at the Materials Research Society Spring Meeting, Phoenix, AZ.
21. INTERNATIONAL ATOMIC ENERGY AGENCY, Deployment Indicators for Small Modular Reactors, IAEA-TECDOC-1854, IAEA, Vienna (2018).
22. Jaques, B.J., Pedersen, S.V., Croteau, J., Lupercio, A., Bellomy, R., Kempf, N.,… Butt, D.P. (2018, March). *Novel synthesis and optimization of half-Heusler materials for thermoelectric applications*. Paper presented at the TMS 2018 Conference, Phoenix, AZ.

23. Kempf, N., Chinnathambi, K., Gigax, J., Shao, L., Jaques, B.J., Butt, D.P., Ren, Z., & Zhang,Y. (2018) Proton irradiation effect on thermoelectric properties of nanostructured n-type half-Heusler Hf0.25Zr0.75NiSn0.99Sb0.01. Applied Physics Letters 112(24). DOI: 10.1063/1.502507

24. Kundu, A., Charit, I., Jaques, B.J., & Jiang, C. (2018, March). *A study on the high energy ball milling and spark plasma sintering of Fe-Cr based alloys*. Paper presented at the TMS 2018 Conference, Phoenix, AZ.

25. Lenhart, S. (2018, September). *Innovation in community electric power: Distributed energy resources in municipal utilities and electric cooperatives in the US.* Paper presented at EPRC8, Boise, ID.

26. Lewandowska, K., Seas, M., Pandhi, T., Chandnani, A., Subbaraman, H., Johnson, P., & Estrada, D. (2017, November). *Powder River Basin graphene inks*. Poster session presented at the Society of Hispanic Professional Engineers (SHPE) National Conference, Kansas City, MO.

27. Li, L. (2018, August). *Computational modeling capabilities and deliverables (I3 Project)*. Poster session presented at the Materials Science Roadmap and Capabilities Meeting, Boise, ID.

28. Li, L. (2018, March). *High-throughput computational studies of structural, electrical, phonon and thermal properties of two-dimensional materials.* Paper presented at the Materials Society conference, Phoenix, AZ.

29. Li, L. (2018, January). *High-throughput computational studies of two-dimensional transition metal dichalcogenides*. Paper presented at the 2018 Conference on Electronic and Advanced Materials, Orlando, FL.

30. Li, L. (2018, January). *Tuning thermal transport in two-dimensional transition metal dichalcogenides*. Paper presented at the 2018 Conference on Electronic and Advanced Materials, Orlando, FL.

31. Li, L. (2018, March). *Tuning electrical and thermal transport in atomic layer materials*. Paper presented at the Materials Society conference, Phoenix, AZ.

32. Li, L. (2018, August). *Phase-field modelling of nanoparticle sintering for Cu-Ni alloy printing.* Poster session presented at the Materials Science Roadmap and Capabilities Meeting, Boise, ID.

33. Li, L. (2018, March). *Predict corrosion phenomena and surface properties of Al-based alloys.* Paper presented at the Materials Society conference, Phoenix, AZ.

34. M., Solan, D., & Shropshire, D. (2015). Carbon free energy development and the role of small modular reactors: A review and decision framework for deployment in developing countries. *Renewable and Sustainable Energy Reviews, 43*, 83-94.

35. Ma, C., Fu, Z., Deng, C., Liao, X., He, Y., Ma, Z., & Xiong, H. (2018). Carbon-coated FeP nanoparticles anchored on carbon nanotube networks as anode for long-life sodium-ion storage. Chemical Communications, 2018,54, 11348-11351. DOI: 10.1039/C8CC06291A

36. Mao, K., Wu, Y., Sun, C., Perez, E., & Wharry, J.P. Laser weld-induced formation of amorphous Mn–Si precipitate in 304 stainless steel, Materialia, Volume 3, 2018, Pages 174-177, ISSN 2589-1529, https://doi.org/10.1016/j.mtla.2018.08.012.

37. Mao, K., Wang, H., Wu, Y., Tomar, V., Wharry, J., Microstructure-property relationship for AISI 304/308L stainless steel laser weldment, Materials Science and Engineering: A, Volume 721, 2018, Pages 234-243, ISSN 0921-5093, https://doi.org/10.1016/j.msea.2018.02.092.

38. O'Brien, R.C., & Lessing, P.A. (2017). Controlled relative humidity storage for high toughness and strength of binderless green pellets. *Journal of the American Ceramic Society 100*(10), 4442-4449.

39. Oh, S. & Gardner, J. (2017, December). Impact of window replacement on Yanke Building energy consumption. (CEERI report 17-001).

40. Pandhi, T., Estrada, D., & Koehne, J. (2018, May). *Inkjet printing of graphene for wearable and flexible electrochemical sensors*. Paper presented at the 233rd Electrochemical Society Meeting, Seattle, WA.

41. Pandhi, T., Estrada, D., & Koehne, J. (2018, June). *Fully inkjet printed graphene-based biosensor for flexible and wearable electronics*. Poster session presented at the 28th World Congress on Biosensors, Miami, FL.

42. Pandhi, T., Kreit, E.B., Aga, R.S., Fujimoto, K., Sharbati, M., Khademi, S.,…Estrada, D. (2018, April). *Emerging 1-D and 2-D materials for printed and flexible electronics*. Poster session presented at the NASA In-Space Manufacturing and Printed Electronics Workshop, Huntsville, AL.

43. Pasebani, S., Charit, I., Guria, A., Wu, Y., Burns, J., Butt, D., Cole, J., & Shao, L. A preliminary investigation of high dose ion irradiation response of a lanthana-bearing nanostructured ferritic steel processed via spark plasma sintering, Journal of Nuclear Materials, Volume 495, 2017, Pages 78-84, ISSN 0022-3115, https://doi.org/10.1016/j.jnucmat.2017.08.010.

44. Patil, C., & Cooper, E. (2018, July). *The use of a 3D sonic anemometer for the study of airflow patterns in a hospital patient room*. Paper presented at Indoor Air Philadelphia, Philadelphia, PA.

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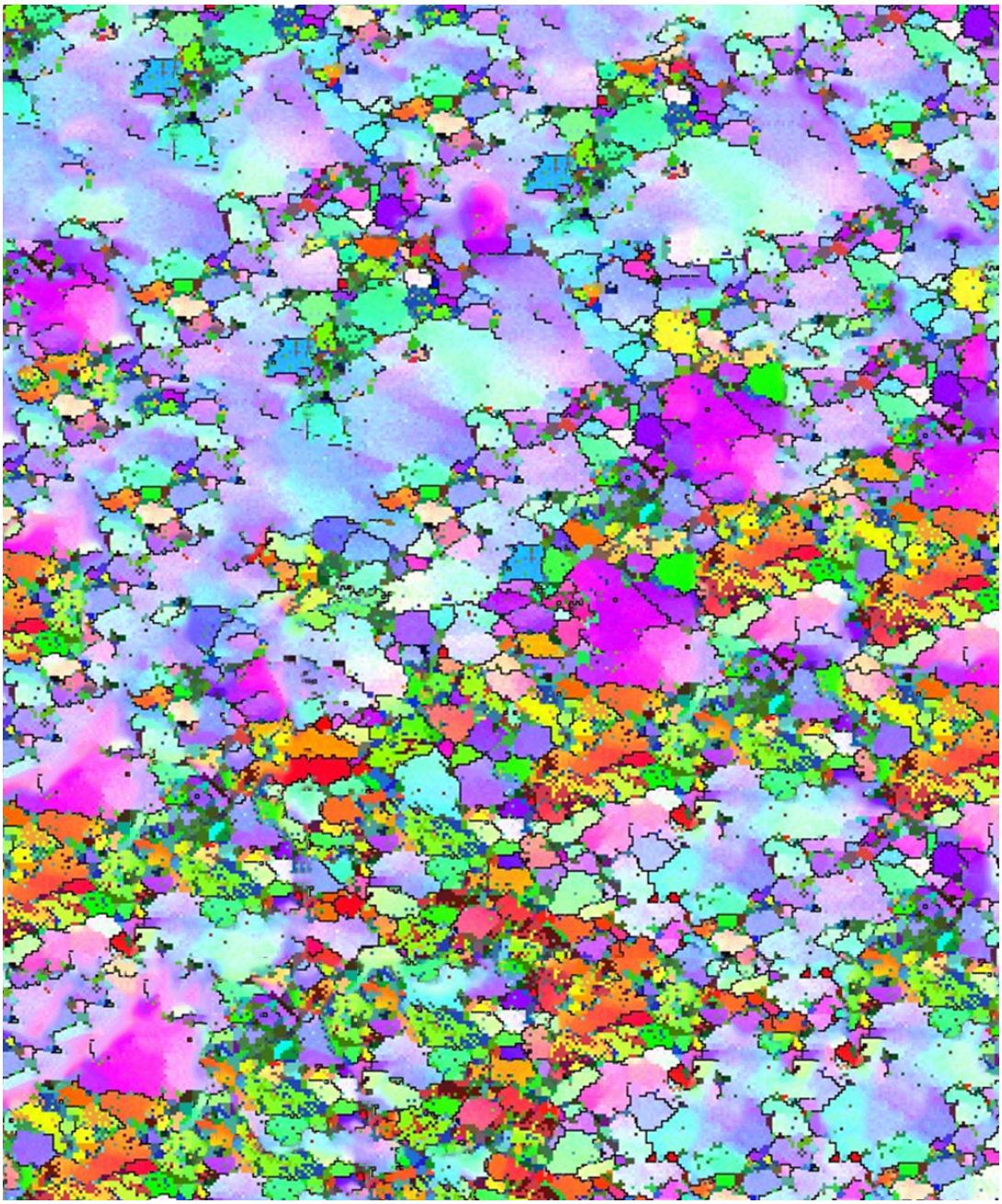

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Cathleen McHugh
June 20, 2019

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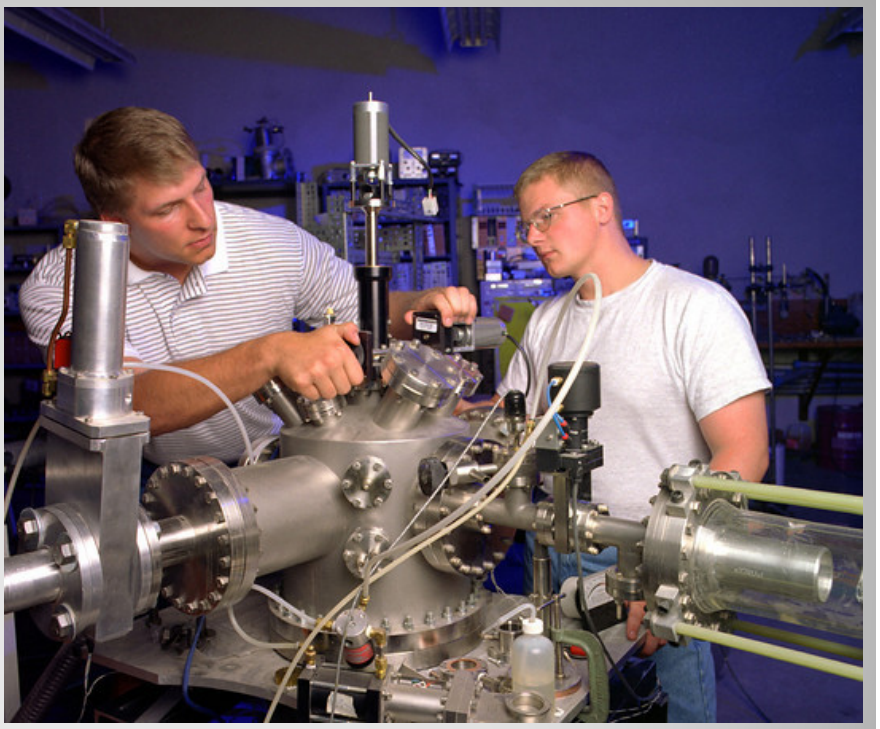

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Idaho State Board of Education

FY19 Undergraduate Research

Supports STEM undergraduate in research projects and undergraduate travel to conferences

* 17 BSU students
* 24 ISU students
* 15 UI students
* 7 LCSC students

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2018 Idaho Conference on Undergraduate Research (ICUR)

Funding for two day conference held at Boise State University in late July 2018. There were approximately 300 attendees with 164 poster presentations and 94 faculty, industry, and governmental representatives.

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FY19 HERC IGEM Projects

Year 3: Security Management of Cyber Physical Control Systems, *University of Idaho, $700,000*

Year 1: Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management, *University of Idaho, $700,000*

Year 1: Nucleic Acid Memory, *Boise State University, $666,500*

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Center for Advanced Energy Studies

- Purpose (from the perspective of the State) – Leverage the capabilities of the Idaho National Lab to the benefit of the State
- Principle – CAES is mutually beneficial for universities, INL, and industry
- Process – Joint proposals to funding agencies {mostly federal}

Center for Advanced Energy Studies

CAES develops and wins proposals for relevant research leveraging INL and University capabilities

- Key assets:
  - CAES building
  - Capabilities at the universities
  - Access to INL personnel and equipment
- Benefits:
  - External funding for capability development
  - Elevate Idaho's stature as a research and innovation hub
  - Provide a workforce pipeline to the laboratory and other high-tech industries

Center for Advanced Energy Studies
EXAMPLE PROJECTS

NUCLEAR ENERGY	ADVANCED MANUFACTURING	DEEP EARTH ENERGY STORAGE
• UI, BSU, INL, and Japan-based Sakae Casting, LLC • Develop a used nuclear fuel storage cask • Phase 1 – funded through a one-year $237,000 IGEM grant • Other collaborators - Idaho's Premier Technology, CEI, and Table Rock, LLC, a Virginia-based consulting firm	• Food Northwest and UI • Establish a research, development, and education center for the food industry • Reduce energy and water consumption at food manufacturing facilities • Food Northwest is one of the nation's largest food trade associations, representing more than 500 processors, manufacturers, and suppliers in ID, OR, WA	• INL, Lawrence Berkeley National Laboratory, UI, and Univ. of Wyoming • Store excess heat from industrial processes in deep underground reservoir systems • Awarded $300,000 through the DOE • Use the earth's rock bed as a natural battery to store grid-scale energy for later usage

Thank You

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